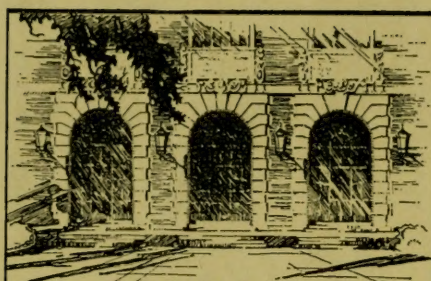




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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
NATURAL HISTORY SURVEY DIVISION
STEPHEN A. FORBES, *Chief*

BULLETIN
OF THE
Illinois State Natural History
Survey

URBANA, ILLINOIS, U. S. A.

Vol. XVIII

CONTENTS AND INDEX

1929-1930



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STATE OF ILLINOIS
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STEPHEN A. FORBES, *Chief*

Vol. XVIII. BULLETIN Article I.

The Native and Naturalized Trees of Illinois

ROBERT BARCLAY MILLER
Chief Forester, Department of Conservation

and

L. R. TEHON
Botanist, State Natural History Survey



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H. C. OESTERLING, *Editor*



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1929

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FOREWORD

The following report on "The Native and Naturalized Trees of Illinois" is a part of the product of a forest survey of the State begun by the State Natural History Survey in 1919 and ended, as to the collection and organization of its data, in 1925. The senior author was a member of the State Survey from its commencement until June 30th of the latter year, and towards the end of this period he assembled the data of this report from all available sources, including, of course, those of the Survey itself, and prepared and filed for publication a comprehensive manuscript, to which some additions were made by him after his appointment as Chief Forester of the State Department of Conservation. In order to make this the best possible product of the botanical resources of the Natural History Survey and of the University of Illinois, it was submitted, for critical revision and completion to the junior author, who was favored with the unstinted advice and assistance of Dr. William Trelease, professor *emeritus* and former head of the Department of Botany of the University of Illinois; and with all these agencies in cordial cooperation, it can be confidently offered to its public as an authoritative compend of the existing state of our knowledge concerning the trees of Illinois.

STEPHEN A. FORBES

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INTRODUCTION

In presenting this book to the people of Illinois, it has been the authors' aim to furnish not merely a manual of the trees of the State but to give as complete an account of them as our present knowledge would permit. Consequently, the reader will find in the following pages not only a means for identifying trees but also the important facts concerning their distribution, their history, their uses, their past and present importance in commerce and industry, and many other things.

As a background for the book, there have been available not only the large collections of specimens made by previous workers and now widely scattered among the herbaria of our universities, colleges, and museums but also a great fund of data and observations gathered by the Natural History Survey's staff of foresters during the course of a thorough and painstaking survey of the forests and wooded lands of the State. From these records and observations, and from the printed reports and communicated experiences of the botanists now actively engaged in studying our trees, it has been possible to select a fund of information bearing upon the distribution of each species, upon its relations to soil, topography, and situation, upon its form and habits, and upon its commercial usefulness, so large that it has had to be sifted and condensed carefully. Nevertheless, it is believed that the interest and usefulness of the book will be greatly enhanced by the inclusion of this information, which tends to make it particularly a book of the trees of Illinois.

In order to encourage a wider and deeper interest in our trees, a final section has been added, in which the lover of trees, the amateur botanist, and teachers and students in high schools and colleges will find instructions for preparing and keeping collections of the trees of their localities, as well as suggestive material regarding the botanical classification of trees, their gross and microscopic structure, and a short account of the study of trees and the present interest in forest preserves in Illinois.

The body of the book is, quite naturally, devoted to a discussion of the individual trees. The plan for this part is simple. On page 15 the reader will find a section entitled "Keys to the Trees for the Four Seasons." These were prepared by Dr. William Trelease, an eminent botanist who was for years head of the Botany Department in the University of Illinois. He also prepared the lucid statement of how to use them. In spring, in summer, in fall, or in winter, the genus to which a

tree belongs can be determined easily by means of these keys. After the genus has been determined, a reference directs the user of the book to a page where a fuller account of the characteristics of the genus is given. Here one will also find a statement of the total number of species belonging to the genus, their general distribution over the world, the history of the genus, and the number of its species occurring in Illinois. If there are more than one species native to Illinois, a key is given for them, by means of which the exact species may be determined, and a reference leads the user from the key to the page where the botanical characters of the species are printed.

The materials used in the description of each species have been put in a definite order. First comes the scientific name and its author, as a heading; this is followed by a line made up of one or more common names; and the text begins with a catalog of the botanical characteristics, which is succeeded in turn by a discussion of distribution, and this in its turn is followed by a statement of the uses to which a tree may be put.

The scientific names and authors are those given in C. S. Sargent's "Manual of the Trees of North America," second edition¹; and the common names are also given largely on the same authority, though we have not hesitated to employ other names when we know them to be used commonly in Illinois. Simplicity has been the aim in omitting all except the commonest and most easily recognized varieties, although now and then a variety customarily recognized as a distinct kind of tree has been given an individual place. The pleasant task of distinguishing the less readily recognized varieties is left to the reader, as a means of proving his increasing interest and knowledge.

In the botanical description of the species, the use of technical words has been avoided as much as possible, as fine botanical distinctions relating to variations in the shape of leaves and fruits and in the relative abundance and texture of plant hairs are apt to be confusing not only to the novice but also to those of wider experience. The full-page plates used to illustrate each species will show the shapes of leaves and fruits and suggest the differences in hairiness far better than words could describe them. There is, however, a more complete description of other characteristics of trees than is usually found in manuals. The twigs, buds, pith, and other structures are described with respect to their size, their color, and their other characteristics, with the intention of leading the reader to observe closely and to become intimately acquainted with all the parts of the trees he identifies. It is supposed that, for the few

¹ Houghton Mifflin Company. 1922.

trees where it is necessary, the reader can distinguish between the sepals, the petals, the stamens, and the pistils, without any special explanation; and the use of a large array of botanical terms for various flower arrangements has been avoided also. The term *inflorescence* will be understood to mean a large collection or cluster of flowers; the *catkin*, familiar on the willows, will be recognized easily on other trees; the *spike* is an inflorescence in which the individual flowers sit on a central axis; and a *raceme* is an inflorescence in which the individual flowers are joined to a central axis by pedicels.

The range in North America, as given by C. S. Sargent and others, is stated briefly for each species, so that the reader may see how the Illinois range fits in; and the particular features of distribution, range, and habitat peculiar to Illinois are discussed in as much detail as possible, in order to include such interesting facts as former occurrences, unusual sizes, present abundance, and the like.

The maps indicating the distribution of species show by counties, and in two instances by localities, the proved occurrence in each case. The meaning of the symbols on the maps is as follows: Cross-hatching by solid lines running diagonally in a county indicates that the occurrence of a species in that county has been proved by a specimen deposited in a herbarium; similar cross-hatching by broken lines means that the species was found in a county during the course of our forest survey, though no specimen has been kept; and cross-hatching by horizontal lines shows an occurrence reported in some published article, for which a confirmatory specimen has not been seen. The approximate localities in which two of our rarest trees occur are marked by black circles.

Though accurate in themselves, these maps are intended to be regarded also in a broader sense. Even though a species is not recorded for a certain county, its proved occurrence in adjoining counties may be taken to mean that it occurs in the first, provided suitable habitats exist, if the timber has not been cut and destroyed. On the other hand, there are certain species which have only a limited distribution in the State, and these will be found only in their proper habitats in the counties marked for them. Maps such as these could not be complete unless collectors and observers had covered the entire State and had made known the results of their work both by printing their observations and by preserving herbarium specimens as verifications. Herein lies the opportunity for the tree enthusiast; for by collecting in his own locality he will be able to add several trees to the list for his county and will also be contributing worthily to the knowledge of tree geography in Illinois.

As an introduction to the paragraphs concerning the uses of each of the trees, the reader will find a brief statement of the technical qualities of the woods derived from them. From this he may see why the woods from certain trees are desirable for fine building, while the woods of others can serve only for posts or the roughest kinds of construction. To this brief statement, he may add a further understanding by referring to the photomicrographs of woods given on the closing pages of the book.

The inclusion of data obtained by the Natural History Survey's staff of foresters upon the present stands of the important timber species and the potential yields from these stands will serve as a warning of the danger in which Illinois now stands with respect to its future supply of lumber. There was a time when more than 40 per cent of the area of the State was covered by magnificent hardwood forests. Today there is but 8 per cent of its area in forests, and even these have been depleted by the axe and by fire.

Yet at the present time there are 19 large and important industries, constituting in themselves nearly 18 per cent of all the manufacturing enterprises of the State, which are almost completely dependent upon wood as a raw material. And there are, besides, 14 other industries to which a supply of wood is exceedingly important. In the aggregate, these manufacturing give employment to more than 163,000 persons; they have an invested capital amounting to \$547,000,000; they purchase annually \$400,000,000 worth of raw material, sell their manufactured products for \$734,000,000, and add to the wealth of the State the sum of \$334,000,000 each year.

The amount of wood actually produced in Illinois' forests and woodlots is only one-fifth of the amount consumed in the State. The remaining four-fifths is shipped in. As the supply of timber becomes depleted elsewhere, it will become more and more difficult to bring into Illinois a quantity of wood adequate to the needs of her industries, unless definite steps are taken to preserve and improve the remnants of our forests.

Though our present forests are becoming pitifully small and poor in species, when compared with the extensive virgin forests, wealthy in hardwood species, which once existed here, there still remain to us 5 million acres of potential woodland, which can be made to produce from 250 million to 400 million cubic feet of wood, or from one-half to two-thirds of our present consumption. By proper management, the percentage of valuable wood produced can be increased greatly; and from this conservation of her potential forest resources, the State of Illinois will derive tremendous benefits in all lines of industry.

TREES INCLUDED

Although it is fruitless to try to draw a line of demarcation between trees and shrubs, we have endeavored to include every species that attains tree size, whether or not the tree yields lumber, bark-products, fruit, or any other commercial product. Several species, such as the flowering Dogwood and the Hop Hornbeam, which by many would be considered only as large shrubs, have been included, partly because they form a characteristic understory in our forests and partly because they furnish small amounts of often very valuable and useful woods. The treatment accorded the hawthorns is by no means adequate; but they form so difficult a group botanically that we have thought it best only to provide a key by means of which the common tree-like species may be identified.

The number of species given individual treatment in the text is exactly 94; but in addition 3 varieties are treated separately, giving a total of 97 trees. If the 16 species of *Crataegus*, the 8 less important varieties mentioned, the 9 oak hybrids, and the 7 other species mentioned as probably native are added, the total number of tree species in the State may be placed at 137. If all the species of *Crataegus* which attain tree size had been included and if more had been known concerning the kinds of *Malus* present in the State, this number would undoubtedly have been much larger; and the number could still be increased by counting in no less than 18 additional varieties, the occurrence of which we have been unable to validate, though they are reported from Illinois.

TREES EXCLUDED

The exclusion of trees from this account has had to be based in part on the question of expediency. Of the very numerous species of hawthorns, we have retained in the book only such as are relatively common; in handling varieties, we have had to leave out those not easily distinguishable as well as those not capable of being validated. To have included more of this type of information than we have done would have served only to confuse those for whom the book is intended.

Certain other species have been excluded from the book, though they do occur within the State, on grounds that are purely arbitrary. One of the sumachs, *Rhus copalina* Linnaeus, attains tree size on rare occasions in southern Illinois, but in the main it is shrubby and yields at present no valuable product. The Black Haw, *Viburnum prunifolium* Linnaeus, occurs in Richland, Pope, and Johnson counties; but we leave it to be treated as a shrub with the other *Viburnums*. The Button Bush, *Cephalanthus*

occidentalis Linnaeus, though tree-like in its northern range, is only a small shrub less than 15 feet high throughout most of Illinois. The Silver Bell Tree, *Halesia carolina* Linnaeus, is small and shrubby in Massac County, its only known locality in Illinois, though in the South it becomes tree-like; and Hercules' Club, *Aralia spinosa* Linnaeus, also a tree in the South, attains a height of only 15, or at most 20, feet in Pulaski, Johnson, and Pope counties, where it is fairly common. The Ironwood, *Bumelia lycioides* Gaertner, which occurs in Alexander, Pulaski, Pope, and Hardin counties, attains a height of 20 feet or so but yields no valuable wood.

A list of the varieties and species not mentioned in the body of the text but variously reported as native or naturalized in Illinois will be found on pages 285 and 286.

ACKNOWLEDGMENTS

Throughout the preparation of this book, the authors have benefited by the advice, encouragement, and help of many people who have taken a real interest in the work, and to them all we are deeply indebted. Appreciation is due especially to Dr. William Trelease, *emeritus* Professor of Botany in the University of Illinois, for the keys on the first pages of the book and also for the critical opinions, the valuable suggestions, and the unwearied assistance that he gave so freely. Charles Sprague Sargent, recently deceased, and Mr. E. J. Palmer, both of the Arnold Arboretum, rendered valuable help by suggesting species to be added to or omitted from our list. Mr. H. Teuscher, Botanist of the Morton Arboretum, gave freely not only his personal help but also the results of his many hours of labor in herberia; and the Curators of the Field Museum of Natural History, the Arnold Arboretum, the Herbarium of the University of Illinois, and the Shaw Botanical Garden have been universally courteous and generous. To the Field Museum of Natural History thanks are due for the use of tree and bark photographs; to the Forest Products Laboratory at Madison, Wisconsin, for permission to reproduce photomicrographs of wood sections; and especially to Charles C. Deam and the Indiana Department of Conservation for the many full-page plates made from Mr. Deam's excellent photographs.

R. B. MILLER
L. R. TEHON.

KEYS TO THE TREES FOR THE FOUR SEASONS

By William Trelease

A "key" is a means of finding out simply and directly the name of a plant, without having to look over and compare many descriptions or illustrations. Anyone who can use one kind of key will quickly learn how to use another with a little study.

HOW TO USE THE KEYS

In the kind of keys used here, one passes by a succession of subdivided steps from the beginning of the key to a point where the name of his tree is found, just as he might go from the bottom floor of a large building to any room he wished by choosing properly-labeled stairways. As an example of their use, we may take the beautiful and important Tulip Tree.

In the "foliage" key (page 16): The leaves of our specimen are not evergreen, as required in the first full line, **a**, so we go to the second full line, **aa**; they are not small and narrow, as required in **b**, so we go to the second principal subdivision, **bb**; there is only one leaf at a joint of the stem, so the plant must be confined to the **c** subdivision; the leaves are not "compound" like those of a locust or a hickory, so we confine ourselves to the next subdivision, **d**; they are cut into several rather large parts, "lobes," which takes us into subdivision **eee** under **d**; they have several ribs or veins radiating from the base, which tells conclusively that the name of the tree can be found under subdivision **i** of this group; the absence of a milky sap, the broad leaves, and the fact that they seem to have been cut off in a shallow notch at the end leads unquestionably to the Latin name *Liriodendron* that botanists give to the Tulip Tree.

If one were to find the same tree with its tulip-like flowers blossoming, the foliage key would still lead to its name; but on the basis of its flowers, it would be even more quickly named by the "flower" key (page 18), for the flowers are so large and showy that it must go into the first general division, **a**; its petals are not grown together, which places it in subdivision **bb**; since its flowers resemble neither pea nor apple nor cherry blossoms, we go on down to subdivision **cccc** of **bb**; and the fact that the tree is already in foliage and the flowers large and part-colored leads directly to *Liriodendron*.

In autumn, when its "seeds" are being scattered by the wind, though neither leaves nor flowers are present, the "fruit" key (page 19) leads to its name almost as directly. The dry fruit puts it in division **aa**:

what are called seeds really are separate pistils massed about a spike-like axis, but not at all of the "cone" type of the pine or hemlock, so we pass first to the **d** subdivision and under it to the **ee** subdivision; and as the fruits are not nuts, have a thin wing at the end, and overlap in what was one flower, we pass directly into the subdivision **ggg** and to the name *Liriodendron*.

In winter these fruits are seen commonly, yet a Tulip Tree which lacks leaves, flowers, and fruits can be named with equal certainty by the "winter" key (page 21). Not being evergreen, it falls into the division **aa** of this key; one leaf-scar at a joint and the fruit not a pine-like "cone" lead to the subdivision **d**; and the very narrow scar-line around the twig and the wonderful 2-edged buds, in which next year's growth is already found, take one again to *Liriodendron*.

I. KEY TO THE TREES WHEN IN FOLIAGE

	PAGE
a. Leaves evergreen, small and narrow.	
Leaves needle-like; fruit a large cone.....	<i>Pinus</i> 23
Leaves not needle-like nor fruit large.	
Fruit a thin-scaled cone, leafy branches flat and fan-like..	<i>Thuja</i> 41
Fruit like a dry berry; branches not fan-like.....	<i>Juniperus</i> 42
aa. Leaves falling in autumn.	
b. Leaves small and narrow; fruit a small cone.	
Scales of cone thin; leaves needle-like.....	<i>Larix</i> 33
Scales of cone thickened; leaves flat.....	<i>Taxodium</i> 37
bb. Leaves never very small nor fruit a cone.	
c. One leaf at each joint (node) of the stem.	
d. Leaves of one blade or piece (simple).	
e. Margin of leaf entire.	
Sap milky; twigs spiny.....	<i>Maclura</i> 177
Sap not milky, nor twigs spiny.	
Leaf as broad as long.....	<i>Cercis</i> 221
Leaf longer than broad.	
A narrow scar around the twig at each node.	<i>Magnolia</i> 179
Without such a scar.	
Leaf widest above the middle.....	<i>Asimina</i> 185
Widest at or below the middle.	
Underside finely hairy.....	<i>Quercus</i> 110
Leaves not hairy.	
Twigs very slender.....	<i>Celtis</i> 168
Twigs moderately stout.	
Pith with cross-plates.....	<i>Nyssa</i> 254
Pith without cross-plates.....	<i>Diospyros</i> 265
ee. Margin of leaf toothed.	
f. Leaf with several strong veins from the base.	
About as broad as long.....	<i>Tilia</i> 251
Longer than broad.....	<i>Celtis</i> 168
ff. Leaf with only one strong vein from the base.	
Twigs rather spiny.....	<i>Malus</i> 198

Twigs not spiny.	PAGE
g. Leaves single toothed (the teeth entire).	
h. Teeth coarse.	
Leaf about as broad as long.....	Populus 46
Longer than broad.	
Teeth very few.....	Nyssa 254
Teeth many.	
Buds long and sharp.....	Fagus 103
Buds short.	
Leaves widened upwards.....	Quercus 110
Leaves widest at middle.....	Castanea 107
hh. Teeth fine.	
Leaf-stalk with small glands.....	Prunus 210
Leaf-stalk without glands.	
Leaves 5 times as long as broad.....	Salix 59
Leaves broader.	
Bark not scaly.....	Carpinus 93
Bark scaly.	
One side of leaf-base smaller.....	Planera 164
Leaf base symmetrical.....	Amelanchier 202
gg. Leaves doubly toothed (the teeth again toothed).	
One side of leaf-base smaller.....	Ulmus 156
Leaf-base symmetrical.	
Bark scaly.....	Ostrya 94
Bark not scaly, often papery.....	Betula 98
eee. Margin of leaf cut more deeply (lobed).	
i. Leaf with several strong veins from the base.	
Sap milky	Morus 174
Sap not milky; leaves as broad as long.	
Leaves notched at end.....	Liriodendron 182
Leaves maple-like.	
With a narrow scar around each node.....	Platanus 195
Without such a scar.....	Liquidambar 191
ii. Leaf with only one strong vein from the base.	
Mucilaginous and aromatic.....	Sassafras 188
Not mucilaginous nor aromatic.	
Pith star-shaped when cut.....	Quercus 110
Pith round; twigs often spiny.....	Crataegus 205
dd. Each leaf with several blades or leaflets (compound).	
Prickles at base of leaf; leaflets simple.....	Robinia 231
Branched spines on stem; some leaflets compound.....	Gleditsia 226
Without either prickles or spines.	
Pith round in cross-section.....	Gymnocladus 222
Pith star-shaped when cut across; leaflets simple.	
Pith solid when split.....	Carya 71
Pith with cavities.....	Juglans 64
cc. Two leaves at each joint (node) of the stem.	
Leaves simple (of one blade).	
Margin of leaf entire.....	Cornus 260
Leaves lobed	Acer 234
Leaves compound (of several leaflets).	
Leaflets spaced along the stalk.....	Fraxinus 268
Leaflets all from one point.	
Twigs slender; buds small.....	Acer 234
Twigs stout; buds large.....	Aesculus 248
ccc. Three large simple leaves at each node.....	Catalpa 282

II. KEY TO THE TREES WHEN IN FLOWER

	PAGE
a. Flowers showy, with both stamens and pistils.	
b. Petals united.	
Forming a small regular white urn.....	Diospyros 265
Forming an irregular open funnel.....	Catalpa 282
bb. Petals not grown together.	
c. Flower resembling a pea-blossom.	
Large, white, fragrant.....	Robinia 231
Small, pink, scentless.....	Cercis 221
cc. Flower like an apple-blossom.	
Large and very fragrant.....	Malus 198
Small and rather ill-scented.....	Crataegus 205
ccc. Flower a small cherry-blossom.....	Prunus 210
cccc. Flower neither pea-, nor apple-, nor cherry-like.	
d. Appearing before or with the leaves.	
White, in clusters.....	Amelanchier 202
Brownish-red, on the twigs.....	Asimina 185
dd. Appearing after the leaves.	
Small, several on a one-bracted stalk.....	Tilia 251
Moderate, clustered, irregular.....	Aesculus 248
Large, not clustered, regular.	
Uniformly yellowish.....	Magnolia 179
With differently colored center.....	Liriodendron 182
aa. Flowers small, not very showy.	
e. In a flower-like cluster with 4 large white bracts.....	Cornus 260
ee. Without petal-like bracts.	
f. Leaves evergreen, small and narrow.	
Needle-like.....	Pinus 23
Not needle-like.	
On fan-like branches; scale-like.....	Thuja 41
Not on fan-like branches.....	Juniperus 42
ff. Leaves falling in autumn.	
g. Leaves narrow and very small.	
Needle-like.....	Larix 33
Appearing compound.....	Taxodium 37
gg. Leaves larger and veiny.	
h. Some or all of the flowers in catkins.	
i. Stamens and pistils on the same tree.	
j. Leaves simple (of one piece).	
k. Pistillate flowers 1 to 3 together.	
In a prickly bur.....	Castanea 107
In a spiny bur.....	Fagus 103
Each in a small cup.....	Quercus 110
kk. Pistillate flowers in catkins.	
Each flower in a small but enlarging and	
scale-like sac.....	Ostrya 94
Each flower with a scale at base.	
Scales enlarging.....	Carpinus 93
Scales small.....	Betula 98
kkk. Pistillate flowers in a round stalked head.	
Twigs with a narrow scar around each	
node.....	Platanus 195
Without such a scar.....	Liquidambar 191
jj. Leaves compound (of several leaflets).	
Pith solid when split.....	Carya 71
Pith with cavities when split.....	Juglans 64

ii. Stamens and pistils on different trees.	PAGE
Sap milky.	
Twigs somewhat thorny.....	<i>Maclura</i> 177
Twigs not thorny; some leaves lobed.....	<i>Morus</i> 174
Sap not milky.	
Each flower with a small cup at base.....	<i>Populus</i> 46
Without a cup at base.....	<i>Salix</i> 59
hh. Flowers not in catkins.	
i. Branches mostly spiny.....	<i>Gleditsia</i> 226
ii. Not spiny.	
m. Leaves simple.	
n. Mucilaginous and aromatic.....	<i>Sassafras</i> 188
nn. Neither mucilaginous nor aromatic.	
o. Flowers in compact clusters on the twigs; appearing before the leaves.	
Clusters 2 at a node.....	<i>Acer</i> 234
One cluster at a node.	
Leaves double-toothed	<i>Ulmus</i> 156
Leaves single-toothed	<i>Planera</i> 164
oo. Flowers or flower clusters stalked.	
Leaves two at a node.....	<i>Acer</i> 234
Leaves one at a node.	
Twigs moderately stout.....	<i>Nyssa</i> 254
Twigs very slender.....	<i>Celtis</i> 168
mm. Leaves compound.	
p. Two at a node.	
Ovary 2-winged	<i>Acer</i> 234
Ovary 1-winged	<i>Fraxinus</i> 268
pp. One at a node; leaflets compound....	<i>Gymnocladus</i> 222

III. KEY TO THE TREES WHEN IN FRUIT

a. Fruit fleshy when ripe.	
b. Flesh thin, drying.	
Leaves evergreen, small; fruit bitter.....	<i>Juniperus</i> 42
Leaves falling in autumn; fruit with thin sweet flesh.....	<i>Celtis</i> 168
bb. Fruit a mass of pistils with fleshy calyxes; sap milky.	
Fruit scarcely an inch long, edible.....	<i>Morus</i> 174
Fruit round, large, not edible.....	<i>Maclura</i> 177
bbb. Fruits several from each flower, large; seeds large.....	<i>Asimina</i> 185
bbbb. Fruit one from each flower.	
c. With a stony "pit"; only one seed.	
Each fruit in a colored cup.....	<i>Sassafras</i> 188
Fruits not in colored cups.	
Edible	<i>Prunus</i> 210
Not edible.	
In small dense clusters, red.....	<i>Cornus</i> 260
Stalked, purplish or dull.....	<i>Nyssa</i> 254
cc. Without a stony "pit"; seeds several.	
With a firm papery core.....	<i>Malus</i> 198
With a hard bony core.....	<i>Crataegus</i> 205
Without a core.	
Small and sweet, purple.....	<i>Amelanchier</i> 202
Large and astringent, yellow.....	<i>Diospyros</i> 265

	PAGE
aa. Fruit dry when ripe.	
d. Fruit not opening to let the seed out.	
e. Fruit forming a scaly "cone."	
f. Leaves evergreen.	
Cones long, leaves needle-shaped.....	<i>Pinus</i> 23
Cones scarcely an inch long; leaves like scales.....	<i>Thuja</i> 41
ff. Leaves falling in winter; cones small.	
Scales of cone thin.....	<i>Larix</i> 33
Scales of cone thickened.....	<i>Taxodium</i> 37
ee. Fruit not a cone.	
g. Fruit a nut, with large seed.	
Nuts in large, very prickly burs.....	<i>Castanea</i> 107
Nuts in small, warty or spiny husks.....	<i>Fagus</i> 103
Nuts (acorn) with a cup at base.....	<i>Quercus</i> 110
Nuts enclosed in a smooth husk.	
Husk finally opening; pith solid when split.....	<i>Carya</i> 71
Husk not opening; pith with cavities.....	<i>Juglans</i> 64
gg. Fruits small, not winged; seed small.	
Solitary on the ends of fascicled stalks, ridged	
and tubercled	<i>Planera</i> 164
Several on a one-bracted stalk.....	<i>Tilia</i> 251
Massed in a naked, slender-stalked, round ball....	<i>Platanus</i> 195
In catkins.	
Each fruit in a large scale-like sac.....	<i>Ostrya</i> 94
Each with a toothed scale.....	<i>Carpinus</i> 93
ggg. Fruits with thin wings.	
Many, overlapping in each flower.....	<i>Liriodendron</i> 182
Very small, in catkins.....	<i>Betula</i> 98
Neither very large nor very small nor overlapping.	
Two wings, separate.....	<i>Acer</i> 234
Only one wing.	
Fruit circular, flat.....	<i>Ulmus</i> 156
Fruit elongated, flat.....	<i>Fraxinus</i> 268
dd. Fruit opening to let the seed escape.	
h. In a cucumber-like mass from each flower.....	<i>Magnolia</i> 179
hh. In round bur-like heads.....	<i>Liquidambar</i> 191
hhh. In catkins; seeds very small and feathery.	
Each fruit with a thin cup at base.....	<i>Populus</i> 46
Without a cup at base.....	<i>Salix</i> 59
hhhh. Neither in heads or catkins nor massed.	
Pencil-shaped capsules	<i>Catalpa</i> 282
Round capsules	<i>Aesculus</i> 248
Flat pods.	
Pods large and hard.....	<i>Gymnocladus</i> 222
Pods hard-papery.	
An inch or two wide.....	<i>Gleditsia</i> 226
Scarcely half an inch wide.	
Clustered at the nodes.....	<i>Cercis</i> 221
In terminal clusters.....	<i>Robinia</i> 231

IV. KEY TO THE TREES IN WINTER

	PAGE
a. Leaves evergreen, small and narrow.	
Leaves needle-shaped, in clusters.....	<i>Pinus</i> 23
Leaves not scale-like, spreading.....	<i>Juniperus</i> 42
Leaves scale-like, not spreading.	
Twigs flat, branching in a fan-like way.....	<i>Thuja</i> 41
Twigs not fan-like.....	<i>Juniperus</i> 42
aa. Leaves falling in winter, leaving evident scars.	
b. Three scars at a node, or joint, of the stem (whorled).....	<i>Catalpa</i> 282
bb. Two scars at a node (opposite).	
End bud half an inch or more long; twigs thick.....	<i>Aesculus</i> 248
Buds much smaller.	
Leaf-scars very small, on raised bases; twigs slender...	<i>Cornus</i> 260
Leaf-scars narrow, V-shaped.....	<i>Acer</i> 234
Leaf-scars broader and not V-shaped.....	<i>Fraxinus</i> 268
bbb. Only one scar at a node (alternate).	
c. Fruit a "cone."	
Scales of cone thin.....	<i>Larix</i> 33
Scales of cone thickened.....	<i>Taxodium</i> 37
cc. Fruit not a "cone."	
d. With a narrow scar around the twig at each node.	
Buds long, sharp and spreading.....	<i>Fagus</i> 103
Buds not long and sharp.	
Buds with 2 scales meeting at the edges....	<i>Liriodendron</i> 182
Each bud covered by one scale.	
Bud hairy; leaf-scar U-shaped.....	<i>Magnolia</i> 179
Bud not hairy; leaf-scar encircling the bud...	<i>Platanus</i> 195
dd. Without a narrow scar around each node.	
e. Pith usually with cavities, when split.	
Twigs very slender.....	<i>Celtis</i> 168
Twigs moderately thick.	
Twigs and pith angular; leaf-scars large.....	<i>Juglans</i> 64
Twigs round; leaf-scars small.....	<i>Diospyros</i> 265
ee. Pith solid.	
With firmer cross-lines when split.....	<i>Nyssa</i> 254
Without firmer cross-plates.	
f. Sap milky.	
Twigs spiny	<i>Maclura</i> 177
Without spines	<i>Morus</i> 174
ff. Sap not milky.	
g. Twigs very thick; leaf-scars large.....	<i>Gymnocladus</i> 222
gg. Twigs slender or moderate.	
Twigs mucilaginous and aromatic.....	<i>Sassafras</i> 188
Twigs not aromatic.	
h. The small buds covered by the leaf-scars.	
Two prickles at each node.....	<i>Robinia</i> 231
Often with branched thorns.....	<i>Gleditsia</i> 226
hh. None of the buds covered by the leaf-scars.	
End bud without scales (naked).....	<i>Asimina</i> 185
End bud, if present, with specialized scales.	
i. Lowest bud-scale directly over the leaf-scar.	
Only one bud-scale; pith round.....	<i>Salix</i> 59
Several scales; pith angular.....	<i>Populus</i> 46

ii. Lowest scales at the side of bud.	PAGE
j. Pith star-shaped when cut across.	
Three large scars on each leaf-scar...Liquidambar	191
Small scars clustered in groups on each	
large leaf-scar	Carya 71
Numerous small scars on each leaf-scar.	
Twigs angular at end.....	Quercus 110
Twigs round	Castanea 107
jj. Pith flattened, 3-sided; twigs very slender....	Betula 98
jjj. Pith round when cut across.	
k. Commonly with spiny twigs.	
Bud scales fleshy and colored.....	Crataegus 205
Bud scales dry.....	Malus 198
kk. Twigs not spiny.	
Buds becoming sharp and relatively	
long	Amelanchier 202
Buds short or blunt.	
Twigs 3-ridged at the nodes.....	Cercis 221
Twigs not prominently ridged.	
l. Each leaf-scar with 3 scars on it.	
m. Scales in 2 rows on each bud.	
Fruit winged	Ulmus 156
Fruit ridged and warty.....	Planera 164
mm. Scales of buds not in 2 rows.	
Trunk fluted, with smooth bark..	Carpinus 93
Trunk uniformly rounded; bark scaly.	
Twigs with bitter almond flavor..	Prunus 210
Not suggesting bitter almonds....	Ostrya 94
II. Leaf-scars without 3 separate small scars.	
Twigs and buds somewhat hairy....	Diospyros 265
Not hairy, often colored red.....	Tilia 251

THE NATIVE AND NATURALIZED TREES OF ILLINOIS

ROBERT BARCLAY MILLER AND L. R. TEHON

Description of the Species

PINUS LINNAEUS

The Pines

Family PINACEAE

Evergreen, cone-bearing trees, with needle-like leaves in bundles of 2 to 5. Flowers in the form of cones, which are of two kinds: the pollen-bearing cones clustered at the base of the season's shoots; the seed-producing cones on the sides or near the ends of the shoots, maturing at the end of their second or third season and bearing two small, winged seeds at the base of each scale.

There are about 66 species of pines, with a range that includes a very large part of the Northern Hemisphere. In North America there are 28 species, and in Illinois three. Eight of the North American species are classed as "soft pines" and twenty as "pitch pines." Of the three Illinois species, one belongs to the first class and two to the second.

KEY TO THE ILLINOIS PINES

- Leaves commonly 5 in a bundle; cones long-cylindric, stalked, pendant;
cone-scales unarmed **P. Strobus** p. 24
- Leaves 2 or 3 in a bundle; cones ovate or oblong-conical, nearly sessile;
cone scales furnished with weak, usually deciduous prickles.
- Leaves 3-5 inches long..... **P. echinata** p. 29
- Leaves $\frac{3}{4}$ -1 $\frac{1}{4}$ inches long..... **P. Banksiana** p. 28

PINUS STROBUS LINNAEUS

White Pine

The White Pine is a tall, straight tree. In dense stands the trunk rises straight from the ground, without tapering much and without dividing, to a height of 60 feet or more. It is devoid of branches for a long distance upward, but toward the top it bears a small crown of living



FIG. 1. White Pine in the State Park near Polo, Ogle County.

branches. The branches are produced, usually 5 at a time, in a whorl, like the spokes of a wheel, at the top of each year's growth. The long, flexible, blue-green, 3-sided needles grow in bundles of 5. Pollen-bearing cones, about $\frac{1}{3}$ inch long, are clustered, 12 to 18 together, at the base of the growth of the season. The seed-producing cones occur on other twigs, solitary, or in small groups of 2 to 5, near the top of the growth of the season. They are at first stalked, upright, cylindric, and about $\frac{1}{2}$ inch long, but by July of their second year they have become long-stalked, pendant, cylindrical green cones 4 to 6 inches or more in length. Towards autumn, they turn brown, open, and shed their seeds; and during the following winter and spring they fall from the trees. The bark on mature trees is dark gray, fairly thick, and is divided by shallow, longitudinal, connecting fissures into broad, continuous ridges, such as appear on the trunk of the closest tree in Figure 1.

Distribution: The present range of the White Pine is far to the north and east of Illinois; but in past times this tree was common throughout the northern third of the State. Now it is represented only by a few scattered remnants, the best known being a tract of 193 acres now a State Park near Polo in Ogle County. This grove, similar to the best found in New England, stands at a considerable elevation above Pine Creek, on a rather deep, sandy-loam soil that is fairly well supplied with water—the characteristic habitat. The trees are about 80 years old. Some of them have attained a height of 90 feet and a diameter of 27 inches; and



PLATE 1

PINUS STROBUS LINNAEUS

WHITE PINE

their volume has increased at a rate of 85 cubic feet per acre annually. Fine trees which have grown to a height of 62 feet in 40 years and have reached a diameter (at breast height) of 17½ inches, have been found in sandy land and here and there in the valley of the Illinois River and its tributaries. By way of contrast, black oak becomes only 42 feet high and 8 inches in diameter in the same time.

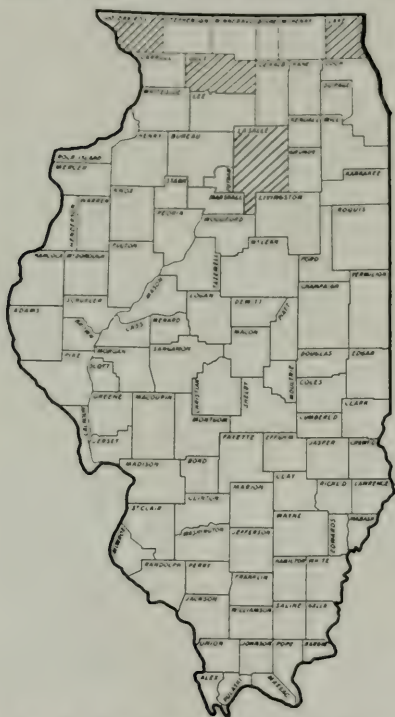


FIG. 2. Distribution of White Pine.

easily worked. It is excellent for planing-mill products, boxes, crates, novelties, matches and many other things. It is one of the best woods for pattern making, but on account of its high price in Illinois, California sugar pine and other woods are being used in its place. It dries easily and does not shrink or swell greatly when its moisture content changes. It is remarkably durable. Many of the oldest houses in New England were built of it, even to the shingles on the roof.

A fine grove formerly existed on the banks of the Spoon River, near Dahinda, in Knox County; but it has been cut, and no trees can be found there now. In the Apple River Canyon in Jo Daviess County, the trees are faring better, for though some of the original stand has disappeared, there is at least one large area where numerous seedlings have taken root and are making a good growth.

The White Pine has been grown successfully at Oregon, Illinois, and it promises to be a useful tree for planting on sandy lands.

Uses: The White Pine, by the lumber trade called also "northern pine" and "eastern white pine", is one of the soft pines. Its wood is soft,



PLATE 2

PINUS BANKSIANA LAMBERT

JACK PINE

PINUS BANKSIANA LAMBERT

Jack Pine

Gray Pine

The Jack Pine is a tree of varied habit. Usually it is small, 15 to 40 feet high, with an open, stunted, irregular crown, which begins nearly at the ground. Its stout, stiff leaves, between $\frac{3}{4}$ and $1\frac{1}{4}$ inches long, grow in bundles of 2 and generally are curved and twisted. The oblong staminate cones occur in large clusters at the base of the new growth. The smaller, globular ovulate cones stand in clusters of 2 to 4 on the sides of the shoots and, as they grow, they become oblong-conical, $1\frac{1}{2}$ to 2 inches long, strongly curved, and turn to a light yellow. They remain closed for several years, but after they have shed their brownish-black, winged seeds, they cling to the tree for a decade or more. The trunks of fine trees may reach a height of 60 or 70 feet and a diameter of 15 inches, or more; and the thin, red-tinted, dark-brown bark is divided irregularly into narrow, rounded, scaly ridges.



FIG. 3. Distribution of the Jack Pine.

The present range of the tree is to the north of Illinois, but it has been able to survive in favorable situations in this State. Preferring sunlight for the germination of its seeds and for growth, the Jack Pine is to be found on poor, sandy soils and on burned-over barren land. Pepoon¹ states that the tree still occurs near Lake Michigan on the Waukegan sand moors.

Distribution: The records that have been available show that the Jack Pine has been found in Lake, Cook, DuPage, and Ogle counties. The present range of the tree is to the north of Illinois, but it has been able to survive in favorable situations in this State. Preferring sunlight for

the germination of its seeds and for growth, the Jack Pine is to be found on poor, sandy soils and on burned-over barren land. Pepoon¹ states that the tree still occurs near Lake Michigan on the Waukegan sand moors.

Uses: When growing in open stands on barren lands, the Jack Pine has the form of an orchard tree, with a short bole and an open, spreading crown. Its wood is then of little value; but in denser stands the trunk is

¹ Flora of the Chicago Region, p. 157.

fairly tall and straight, with only a small crown, and gives logs of value for rough uses. In the Lake States, the tree was looked upon formerly as a weed tree, for the wood, which is light, soft, weak, and close-grained, was not durable in the soil and could not be used for posts. But after the development of methods for treating timber to prevent rotting, the wood could be used for railroad ties; and it is now employed, mixed with other woods, in manufacturing paper pulp.

In Minnesota, stands are producing annually six railroad ties and a cord of other merchantable material per acre; and Allison² says that on second-rate agricultural soils it should grow to a height of 45 or 50 feet and a diameter (at breast height) of 11 inches. In Canada,³ it is depended upon to produce not less than $\frac{3}{4}$ of a cord of wood per acre annually through its growth period of 40 to 50 years. In Illinois, its usefulness is limited, however, as other pines appear more suitable for our sand barrens.

PINUS ECHINATA MILLER

Yellow Pine

Short-leaf Pine

The Yellow Pine is a tall, straight, slender-trunked tree, capped by a large, oval or round head of living branches. The dark blue-green leaves are soft and flexible, finely toothed, abruptly pointed, 3 to 5 inches long, and bound in fascicles of two or three. The nearly sessile staminate cones are about $\frac{3}{4}$ inch long. Pistillate cones occur in pairs, or in groups of 3 or 4, near the end of the season's growth on short, stout stalks. At maturity they reach a length of $1\frac{1}{2}$ to 2 inches (the smallest of all the pine cones), and become chestnut-brown. Old cones remain attached to the branches for several years. The ends of the cone scales are slightly thickened and bear weak, deciduous prickles. The trunk reaches a height of 80 to 100 feet and a diameter of 3 to 4 feet. The cinnamon-red bark, sometimes an inch thick, is divided into irregularly angular, scaly plates by a network of deep fissures.

Distribution: The present range of the Yellow Pine, or Short-leaf Pine as it is also called, lies chiefly to the south and west of Illinois, but the tree occurs in two localities in the southern part of the State. The larger stand occupies a tract of about 200 acres on the hills in Union County near Wolf Lake, and the smaller stand grows in a sandstone ravine of Piney Creek, near the town of West Point in Randolph County. The

² Forestry Quarterly 21: 796. 1923.

³ Tree Pamphlet No. 7. Forestry Branch, Department of the Interior. Ottawa, Canada.



PLATE 3

PINUS ECHINATA MILLER

SHORT-LEAF PINE

Wolf Lake stand was mentioned years ago by Dr. S. A. Forbes under the name *Pinus mitis*. According to Dr. Schneck, the Short-leaf Pine formerly grew on the hills in Gallatin County, near the mouth of the Wabash River; but Sargent believes that the tree must have been *Pinus virginiana*, the eastern Scrub Pine, which is found on the "knobs" of southern Indiana, and Deam¹ refers all records of the Short-leaf Pine in Indiana to this species.

The Short-leaf Pine usually grows in pure stands, though east of the Mississippi River it often is mixed with hardwoods. It thrives in well-drained, light, sandy, and gravelly soils. The "Pine Hills" of Union County, on which it grows, are cherty or gravelly.

Uses: The Short-leaf Pine belongs to the hard pine group, and its wood is difficult to distinguish from the wood of the Long-leaf and Loblolly pines, both of which have similar growth rates. The quality of Short-leaf Pine wood is variable, some of it being almost as light as white pine, and a certain grade is sold under the name "Arkansas soft pine." It is a very useful wood, being utilized commonly for the interior and exterior finishing of houses, for general construction, for manufacturing paper pulp, excelsior, and cooperage stock, as well as mine props, and for numerous other purposes. The small stands of this pine in Illinois naturally are of no economic importance; but some of the trees were cut for lumber in the early days, and there is an old log house, still standing just below the edge of the bluff at Wolf Lake, that was built entirely of hewed Short-leaf Pine logs.

NATURALIZED PINES

In the region just south of the outlet of Dead River, on the sands known as the Waukegan Moorland, there is, in the words of Pepon², "a veritable miniature forest of conifers,

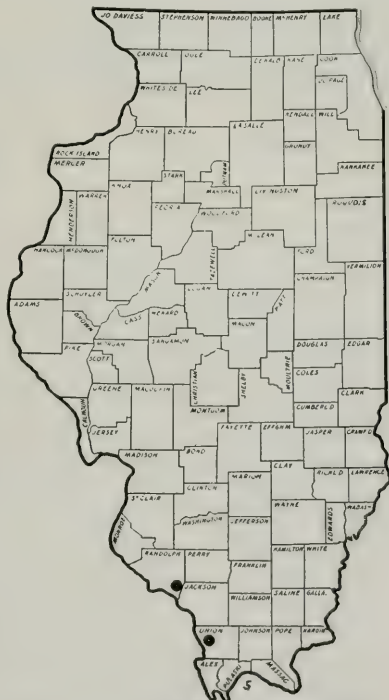


FIG. 4. Distribution of the Yellow Pine.

¹Trees of Indiana, p. 290.

²Flora of the Chicago Region, p. 5.

of many species, the result of wholesale seed sowing some sixty years ago" of Robert Douglass, who "traversed the area on horseback, carrying a



FIG. 5. Yellow Pine on the bluffs overlooking the Mississippi bottoms at Wolf Lake, Union County.

bag of mixed seeds, and threw them into the wind, thus scattering the seed far and wide. Today some parts are covered with a most vigorous forest growth." The pines now present are the White Pine, the Austrian Pine (*P. laricio*), the Scotch Pine (*P. sylvestris*), the Table Mountain Pine (*P. pungens*), and the Pitch Pine (*P. rigida*). "To the unobservant or to the poorly informed observer," says Pepoon, "this growth has every appearance of being natural, and in fact is so for all practical purposes; and if no disturbance occurs in the next generation, the evidence will all point to Nature instead of Art as the causation of the peculiar coniferous flora."



Tamarack bog, Lake County. Photo by W. G. Waterman.

LARIX ADANSON**Larch****Tamarack**

Family PINACEAE

Tall, pyramidal trees with awl-like, deciduous leaves which occur separately, in a spiral arrangement, on the leading shoots but are held, 20 to 50 together, in crowded fascicles on the older branches. Flowers in the form of cones, the staminate cones on leafless, and the pistillate cones on leafy branches; both kinds terminal and solitary, the latter at maturity bearing 2 winged seeds at the base of its scales; each scale in the axis of a persistent bract.

Of the three American species, only one occurs in Illinois.

LARIX LARICINA K. KOCH**Tamarack****Larch**

The Tamarack is a straight tree of moderate height, with long, drooping branches that form an extended, narrow, spire-like head in open stands or, in close stands, a short, open crown. The awl-like, sharply pointed leaves are from $\frac{3}{4}$ to $1\frac{1}{2}$ inches long and are borne in characteristic compact bundles of 20 to 50 at intervals on the older twigs and singly, in a close spiral, on the season's shoots. The staminate cones are borne singly on the tips of short lateral branches on the one- or two-year-old twigs. The ovulate cones are borne at the tips of short, leafy shoots along the sides of one- to three-year-old twigs; and, when they attain maturity in the autumn of the first year, they are chestnut-brown and $\frac{1}{2}$ to $\frac{3}{4}$ inch long. Their 20 or so cone-scales are concave, nearly round, irregularly and shallowly toothed along the margins. The bracts are persistent and only half as long as the scales. The slightly tapering trunk, which rises to a height of 40 or 50 feet and attains a diameter of 15 or sometimes 20 inches, is covered by a reddish-brown, thin, scaly bark.



FIG. 6. Tamarack in a Lake County bog. Photo by W. G. Waterman.



PLATE 4

LARIX LARICINA K. Koch

TAMARACK

Distribution: The Tamarack ranges as a rare and local tree from Newfoundland westward to Alaska and southward into the north of Illinois and Indiana. Its occurrence in Illinois is limited to two counties, McHenry and Lake, where it grows in the interior of deep sphagnum swamps and bogs and along the edges of lakes. Professor W. G. Waterman¹ reports that in the Lake County bogs "the Tamarack forest has been cut in places, but where relatively untouched the growth is dense and there are many trees up to 10 and 12 inches in diameter." The growth of these trees is slow, for Professor Waterman says that "a 4-inch stump showed 40 to 50 very narrow rings while one 10 inches in diameter showed 75 rings." In the southern part of its general range, the Tamarack grows in cold, deep swamps, in association with black spruce and *Arbor Vitae*; but in Lake County the trees that accompany it are the Birch, the Aspen, and the Mountain Ash.

Uses: The wood of the Tamarack resembles the wood of the hard pines. It is brownish, coarse-grained, and fairly durable, and has a thin sapwood. It is used for fence posts, telegraph and telephone poles, and railroad ties; and the large roots are sometimes dug out and, together with a part of the trunk, hewed to form "ship's knees," which are used in the keels of wooden ships. However, the few trees in Illinois have no usefulness beyond the fact that they stand as representatives of an ancient Illinois forest, now long vanished through changing soils and climates.

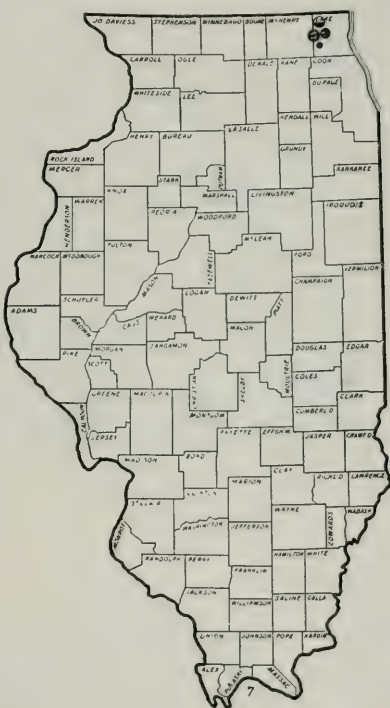


FIG. 7. Distribution of the Tamarack in Illinois.

¹ Trans. Illinois St. Acad. Sci. 16: 220. 1923.

LARIX DECIDUA MILLER**European Larch**

The European Larch, a tree much like the Tamarack, has been grown quite commonly in Illinois for windbreaks and as shade trees; and in favorable situations it makes a good growth. In 1871 Professor T. J. Burrill, of the University of Illinois, planted a plot of $1\frac{1}{4}$ acres in the Forest Tree Plantation at Urbana with one-year-old seedlings; and 48 years later (in 1919), when a $\frac{1}{4}$ -acre plot was measured, the trees were found to have grown an average of 111 cubic feet per acre annually. The trees on higher ground had done very much better than those planted in the wetter places.

The usefulness of this tree in northern Illinois is indicated by the fact that in 1872 Robert Douglas, a nurseryman of Waukegan already mentioned in connection with the naturalized pine forest near that city, exhibited, at a meeting of the Illinois Horticultural Society, some specimens of the European Larch, one of which was about a foot in diameter—an average growth of nearly an inch for each of the tree's thirteen years.

It is stated by Peppoon¹ that the European Larch is now "occasionally spontaneous about towns and along railways" in the Chicago region, "where it is planted as a snow protection."

TAXODIUM RICHARD**Bald Cypress**

Family PINACEAE

Deciduous, cone-bearing trees, with scale-like and needle-like leaves that are borne singly and disposed respectively in close spirals or in two ranks on the lateral twigs. Flowers in the form of cones; staminate cones in terminal, scaly-leaved panicles; ovulate cones scattered on the ends of year-old branches, maturing the first year. Seeds in pairs under each cone-scale; each seed with 3 thick lateral wings and a long slender point.

Although in ancient geological ages the genus was widely distributed over North America and Europe, it is confined now to the North American continent, where there are two species, one of which occurs in the United States.

¹ Flora of the Chicago Region, p. 157.



FIG. 8. European Larch in the Forest Tree Plantation of the University of Illinois.



FIG. 9. Bald Cypress trunks in a virgin forest, Massac County.



PLATE 5

TAXODIUM DISTICHUM RICHARD

BALD CYPRESS

TAXODIUM DISTICHUM RICHARD

Bald Cypress

Deciduous Cypress

The Bald Cypress is a tall, straight tree, with long, slender branches that give young trees a narrow, pyramidal shape, but on old trees spread out to form a very broad, low crown. The short lateral branchlets usually extend nearly at right angles to their supporting branch and fall from the tree at the end of the season. The leaves are of two kinds, appearing on some vegetative twigs in 2 ranks as linear, pointed, yellowish-green needles $\frac{1}{2}$ to $\frac{3}{4}$ inch long, and on the stamiferous panicles and other vegetative twigs as spirally-arranged, appressed scales. The numerous staminate cones are borne on long panicles on the season's growth. The ovulate cones usually are borne in pairs (but not opposite each other) toward the ends of one-year-old branches; and at maturity they appear as woody balls about 1 inch in diameter, made up of closely fitted scales. The straight trunk, which often attains a height of 150 feet and a diameter of 4 or 5 feet above its broad and buttressed hollow base, is clothed with cinnamon-red bark 1 to 2 inches thick, which is divided by narrow fissures into broad, flat ridges. In natural situations, the roots send up woody growths, the "cypress knees," through the ground and water above.

Distribution: The range of the Bald Cypress extends from southern Delaware southward along the Atlantic coast to Florida, westward through the Gulf region to Texas, and northward by way of the valleys of the Mississippi and its tributaries to southern Illinois and Indiana. In Illinois, at the present time, it is growing in the Mississippi bottoms in Alexander and Union counties and is, besides, an important tree in the bottomland forests of the Ohio, the Cache, and the Wabash rivers. It extends northward along the Wabash River to the southern part of Wabash County and, according to Hall and Ingall¹, it grew in Hamilton County previous to 1909.

Throughout its range in Illinois, the Bald Cypress is associated, as a dominant tree, with the Tupelo and the Red and Black gums in the forest that occupies the low and swampy bottomlands of the Mississippi, the Ohio, and the lower Wabash; and in these situations grow also the Pecan, Water Hickory, Soft Maple, Sycamore, Ash, Elm, Hackberry, Honey Locust, cottonwoods, and the water-tolerating oaks.

Uses: The wood of the Bald Cypress is light, soft, and straight-grained, and has a characteristic greasy feeling when it is rubbed. The growth rings are often double, and there are numerous resin cells but no resin ducts. The lumber trade recognizes a special grade, known as

¹ State Lab. Nat. Hist. Bul. Vol. 9, Art. 4. 1911.

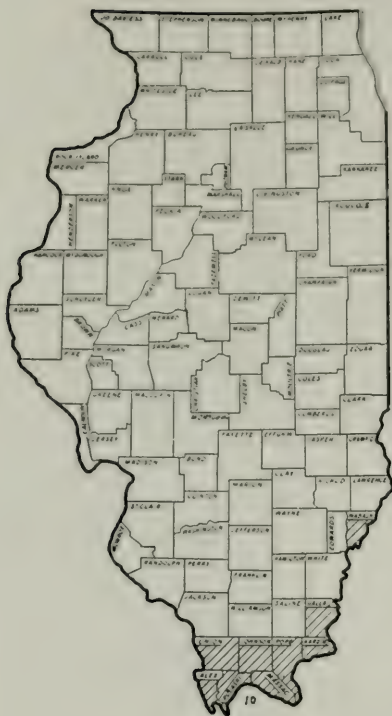


FIG. 10. Distribution of the Bald Cypress.

"pecky" or "peggy" cypress, which comes from trees attacked by a parasitic fungus. Trees so diseased can not be recognized before they are cut; but, as the decay stops with the death of the tree, the lumber is still usable for crating and other purposes where strength is not required.

Since cypress responds well to paints, enamels, and varnishes, it is in demand for ceilings, wainscoting, and flooring; and, as striking effects can be secured, it is in demand also for panels and doors. Its durability when exposed to water and weather makes it a desirable wood for drain-boards and kitchen cupboards in homes, as well as for constructing greenhouses, silos, tanks, coffins, boats, and ships, and for posts, poles, and railroad ties. Cypress shingles² last for 15 to 30 years, equaling the durability of cedar and exceeding the durability of all other American woods used for that purpose.

The Bald Cypress has been cut for lumber in all the counties marked in Figure 10, and according to the Census Reports the yield of lumber has ranged from 1,135,000 board feet in 1899 to 2,228,000 board feet in 1919. The original cypress forest, estimated to have covered, in mixed and pure stands, an area of approximately 250,000 acres³, has been reduced by cutting to about 21,000 acres of commercial timber, and the yield in 1925 was only 700,000 board feet. The settlement of the forest land and its reclamation to agricultural purposes by drainage are setting up conditions that not only prevent the re-establishment of cypress in the cut-over forest but even result in the death of established trees. Where the forest land is not otherwise used, the new soil conditions allow hardwoods such as the Maple, Ash, Elm, and Cottonwood to take precedence. Already this once abundant tree has been exploited to the full; and it is, indeed, but a matter of years till the cypress will exist only in the small and isolated remnants of a once magnificent forest.

² See N. C. Brown's *Forest Products: Their Manufacture and Use*. 1919. Page 369.

³ State Nat. Hist. Surv. Bul. 16: 12. 1926.

or three stout, upright secondary stems, and it often is lobed and buttressed at the base. The light, red-tinted mature bark, $\frac{1}{4}$ inch thick, is broken into narrow ridges by shallow fissures.

Distribution: The range of the Arbor Vitae extends westward from Nova Scotia to the Saskatchewan and southward, along the mountains, to North Carolina, Virginia, and Tennessee; but the tree is found in Illinois only in the northeast corner of the State, where it is associated with the Tamarack in the bogs of Lake County and persists as an isolated remnant of larger stands in the Elgin City Park, as one of the trees clothing historic Starved Rock, "and on 'springy' bluffs" at Highland Park¹ in Cook County. These situations are characteristic of its natural habitat in the far north.

Uses: The aromatic, brown-tinted, yellow wood of the Arbor Vitae, known in the lumber trade as "northern white cedar," is light, soft, brittle, and straight though coarsely grained. Like the wood of other swamp-inhabiting evergreens, it is durable; and because of this it serves excellently for railroad ties, poles, posts, and shingles, as well as for manufactured articles, such as canoes, where its lightness is also an asset.

JUNIPERUS LINNAEUS

Red Cedar

Family PINACEAE

Small, aromatic, evergreen trees and shrubs, with slender branches. The leaves are awl-like or scale-like and are borne in whorls of three, oppositely in pairs, or alternately. Flowers in the form of cones, axillary, or terminal on short axillary branches grown from buds of the previous autumn; ovulate cones maturing into a fleshy, berry-like fruit.

This is a genus of many species and with a range that extends throughout a great part of the Northern Hemisphere. There are about a dozen species in North America, some being trees and some low shrubs. Of the two species in Illinois, one is a tree.

JUNIPERUS VIRGINIANA LINNAEUS

Red Cedar

Savin

The Red Cedar is a small, straight tree, with slender, horizontal or ascending branches that form a narrow, compact, conical crown. The dark blue-green, sharply pointed leaves, which stand in four ranks formed by the alternate placement of pairs, are of two kinds, one scale-like and about $\frac{1}{16}$ inch long, the other awl-like and from $\frac{1}{4}$ to $\frac{3}{4}$ inch long. The

¹ Flora of the Chicago Region, p. 157.



PLATE 6

THUJA OCCIDENTALIS LINNAEUS

ARBOR VITAE



PLATE 7

JUNIPERUS VIRGINIANA LINNAEUS

RED CEDAR

staminate and ovulate cones are borne on separate trees; and the ovulate cones mature, in autumn of the first year, as globose, dark-blue, glaucous berries, which bear 1 or 2 small, brown, wingless seeds on each of their fleshy, coherent scales. The straight trunk, which attains a height of 20 to 50 feet and a diameter of 1 to 2 feet, often is lobed, eccentric, and buttressed at the base; and its thin, red-tinted, brown bark peels off in long, narrow, fibrous strips.

Distribution: The Red Cedar ranges from Nova Scotia southwestward to eastern North Dakota and southward to Florida and Texas. Throughout this territory it thrives in a wide range of situations, preferring abandoned fields, wastelands, and rocky, limestone cliffs, but growing well in swamps and bottomlands. It is found throughout the length and breadth of Illinois, where it is by far the commonest and best known of the evergreens. It grows very abundantly on barren and sterile soil. In hilly country, it often forms an evergreen rim on the edges of cliffs.

In southern Illinois, where the Red Cedar is most abundant, it is found frequently in association with the Black Locust and the Black Oak, and farther north, as in Adams County, it grows with the Black and White oaks and hickory.

Uses: The light, fragrant, fine-grained wood of the Red Cedar is soft and brittle but exceedingly durable, and serves well for fence posts, poles, railroad ties, and in the manufacture of wooden articles which must withstand the weather. Red Cedar railroad ties, untreated, are reported¹ to have a durability of from 12 to 15 years—a record exceeded only by the Black Locust and equalled only by the Northern White Cedar and the Redwood.

The contrast in color between the red heartwood and the white sap wood makes it possible, by proper sawing, to secure a variegated lumber beautifully adapted to certain types of interior finishing. The essential oils that the lumber contains make it useful for moth-proof chests and clothes closets.

Although 600,000 board feet of

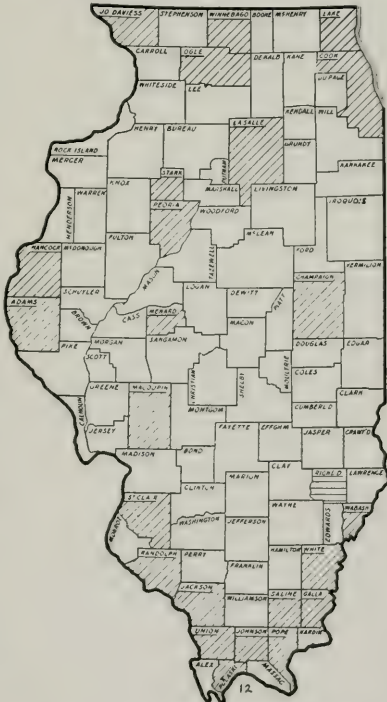


FIG. 12. Distribution of the Red Cedar.

¹ See N. C. Brown's *Forest Products: Their Manufacture and Use*, p. 292.

Red Cedar lumber was produced in Illinois in 1922, the tree cannot be recommended as profitable, for an analysis of the stems of 200 trees taken in 1920 from pure and mixed stands showed that the tree grows very slowly, requiring an average of 50 years to produce 2 fence posts.

The Red Cedar acts as an alternate host for a destructive fungous disease of apples, the apple rust; and for this reason is not recommended for planting, even as an ornamental tree, in the vicinity of apple orchards.

POPULUS LINNAEUS

The Poplars

Family SALICACEAE

Large, rapidly growing, deciduous trees, with broad-bladed, alternately arranged leaves. Flowers in large, pendulous catkins, and of two kinds: the pistillate and staminate flowers appearing on separate trees before the leaves, each flower surrounded by a cup-shaped disk. Twigs of moderate size, round or 5-angled, with small, 5-angled pith and with sessile, solitary, medium-sized buds covered by several thin, resinous scales.

There are 34 recognized species of *Populus*, ranging through the Northern Hemisphere from the Arctic Circle south into Mexico and Northern Africa; and of the 15 species that occur in North America, 4 are found in Illinois.

KEY TO THE ILLINOIS POPLARS

- Leaves 2-3 inches long, with 12 or fewer stout teeth on each side of the blade; buds divergent, hardly resinous, hairy at least on the thin margins of their scales.....*P. grandidentata* p. 50
- Leaves generally in excess of 3 inches long, and with more than 12 teeth on each side of the blade; buds generally appressed, distinctly resinous, and without hairs.
 - Leaf-petioles round; buds small and brown; young twigs and leaves heavily coated with white wool.....*P. heterophylla* p. 52
 - Leaf-petioles flattened laterally; buds red- or chestnut-brown, lustrous; leaves at most hairy; young twigs sometimes woolly.
 - Leaves rather finely toothed, usually less than $3\frac{1}{2}$ inches wide; buds slightly resinous, less than $\frac{3}{8}$ inch long...*P. tremuloides* p. 47
 - Leaves more coarsely toothed, usually $3\frac{1}{2}$ inches wide; buds gummy with resin, more than $\frac{3}{8}$ inch long....*P. balsamifera* p. 54

POPULUS TREMULOIDES MICHAUX

Aspen

Quaking Asp

The Aspen is a small tree, with a narrow, open, round-topped crown consisting of slender, up-tilted branches that droop at the tips. The thin, firm, smooth, lustrous leaves are broadly ovate and have a sharp point and a rounded base. Their margins are finely and regularly toothed, and the petioles are strongly flattened. The cylindrical, hairy catkins, which appear late in March or early in April, are from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long, the staminate catkin reddened by its pollen-sacs. The pistillate catkin matures in May or June, bearing minute brown seeds, each with a tuft of white hair at one end, in curved, thin-walled capsules, about $\frac{1}{4}$ inch long, situated at intervals along the now elongated (3 to 4 inches) stalk. The twigs are slender, smooth, and lustrous, turning reddish-brown and finally gray. The conical, slightly resinous, curved, and pointed leaf-buds, about $\frac{1}{4}$ of an inch long, are covered by 6 or 7 lustrous, hairless, reddish scales and are closely appressed to the twigs, while the larger but otherwise similar flower buds are rather divergent. The trunk, which may attain a diameter of 1 or even 2 feet, is clothed at maturity by nearly black, fissured bark with broad,

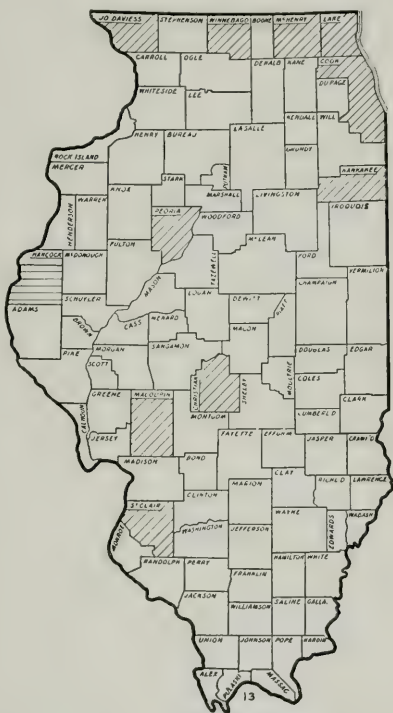


FIG. 13. Distribution of the Aspen.

flat ridges; but on younger trees and higher on the boles of mature trees the bark is thinner, yellow-green to gray, and roughened by wart-like growths. The tree usually attains a height of from 30 to 60 feet.

Distribution: The Aspen in the north has a transcontinental range that extends from southern Labrador westward to Alaska, but southward, on the plains, it extends only through northern Indiana and Illinois into northeastern Missouri. In Illinois it is not a common tree. It has been found as far south as St. Clair County in the west, but according to Robert Ridgway it does not occur in the woods of Wabash County. In the

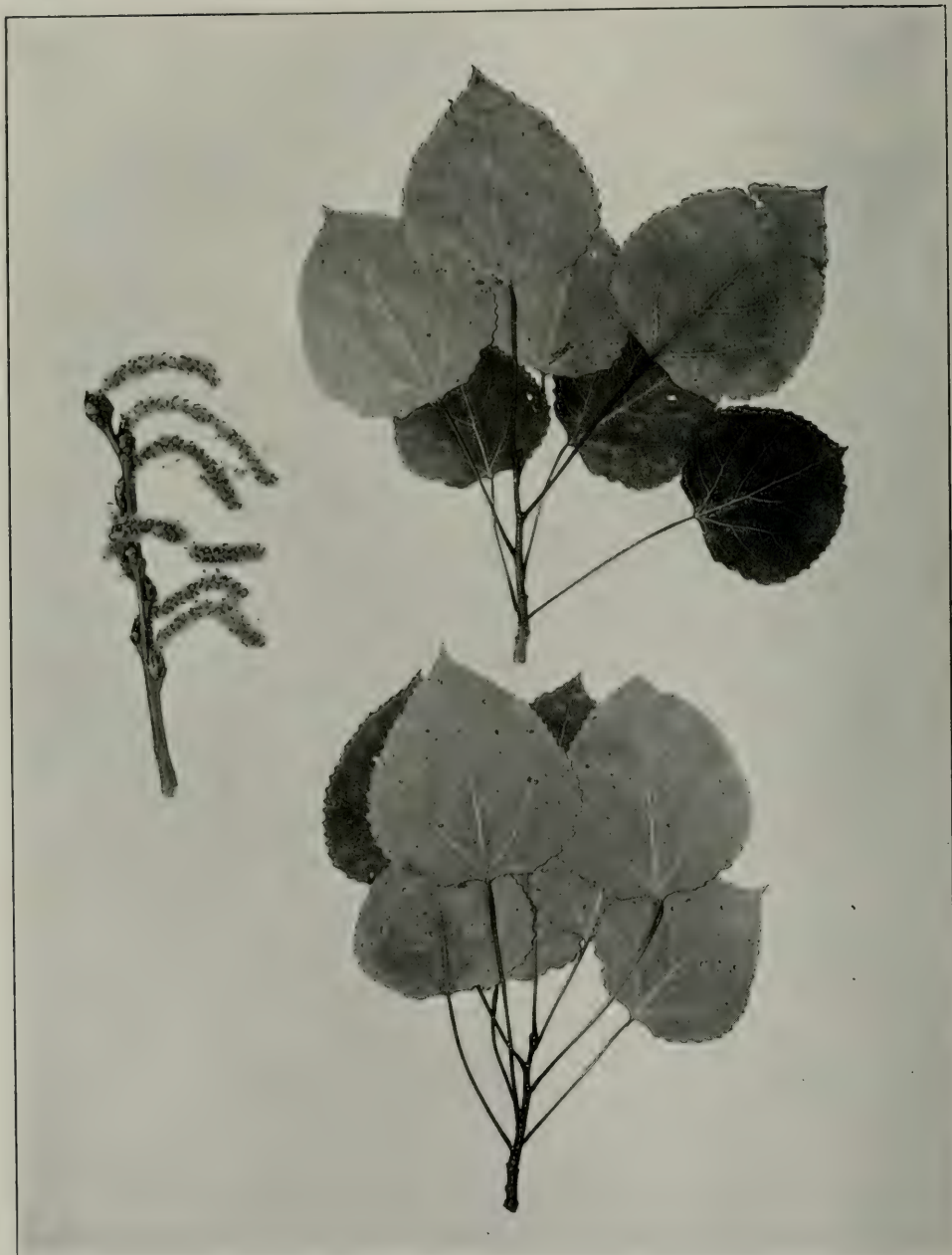


PLATE 8

POPULUS TREMULOIDES MICHAUX

ASPEN



PLATE 9

POPULUS GRANDIDENTATA MICHAUX

POPLAR

beach region north of Waukegan, Gates found Aspen with Burr Oak and hickory. In Lake County he found it on the edges of boggy prairies, while Gleason¹ says that the Aspen is an inhabitant of the swampy swales between the sandy hills and that an occasional tree is found in the Burr Oak association in the sand areas of Winnebago, Lee, and Kankakee Counties. In Whiteside County, we have found it in young stands of oak, hickory, ash, cherry, and Black Locust, presumably on burned-over land, and we have found it in company with poplars on the sides of eroded gullies in Lee and Carroll counties, where it seemed as much a pioneer as on sand and burned-over land.

Uses: The light-brown, close-grained wood of the Aspen is light, soft, and weak, and has few commercial uses. When mixed with spruce and fir, it is used in the manufacture of "sulphate-pulp," and its lumber is used occasionally in turnery. As a fuel wood, it is fair, but it does not have the heating and lasting qualities of birch and maple. The wood is not durable in the soil and so is not satisfactory for fence posts, poles, or ties. But the ability of the tree to establish itself quickly on burned-over or denuded land makes it useful as a protecting cover for slower-growing and more valuable trees.

POPULUS GRANDIDENTATA MICHAUX

Poplar

Large-toothed Aspen

The Poplar is a small to medium-sized tree, with slender, rather rigid branches and stout twigs, which form a narrow, round-topped, and open crown. The thin, firm leaves, though at first white-woolly, are at length smooth and yellow-green, with sharp points and rounded or broadly wedge-shaped bases and petioles strongly flattened at the sides. The cylindrical, hairy catkins, at first $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long, appear in late March and April, the staminate and pistillate catkins being on separate trees. The fruit, which matures in May as the leaves come out, consists of a small, curved capsule, many of which are disposed loosely on the stalk of the mature pistillate catkin, which is then 5 to 6 inches long. The minute brown seeds set free from the capsules are provided at one end with a tuft of white hair. The divergent flower and leaf buds are separate, the broadly ovate, rather pointed leaf buds, which are covered by 6 or 7 rounded, somewhat hairy, chestnut-brown scales, being about $\frac{1}{8}$ inch long, and the flower buds, which are similar, being larger and more divergent. The twigs are rather stout and, though mostly smooth and lustrous,

¹ Ill. State Lab. Nat. Hist. Bul. Vol. 9, Art. 3. 1910.

often gray-hairy toward the tip, with a dark reddish or yellowish brown bark. The trunk, which on old trees is covered by thick, dark-brown bark roughened by irregular fissures and broad, flat ridges, attains a diameter of from 1 to 2 feet. The tree usually is from 25 to 50 feet tall.

Distribution: The Poplar is an inhabitant of rich, sandy soils near the borders of swamps, from Nova Scotia westward to northern Minnesota and southward to central Kentucky and Tennessee. In Illinois, it is to be found in most of the counties in the northern tier; and its range extends southeastward as far as Wabash County, where it has been collected by Jacob Schneck and Robert Ridgway. According to Gleason, it grows with Burr Oak in the sand area at Amboy, Lee County, and also as an occasional pioneer in the Black Oak woods. In the main, the tree prefers rich, sandy soil in the vicinity of streams and swamps, although it is reported in the dry, upland woods of Peoria County and may be found on eroded land and sand dunes.

Uses: The close-grained, pale-brown heartwood and nearly white sapwood of the Poplar (see page 301) is light, soft, and weak. Though used for excelsior and pulp and in the manufacture of small wooden articles, it has little commercial value. The tree itself, because it grows rapidly on burned or barren land, is useful as a covering beneath which more valuable trees can establish themselves.

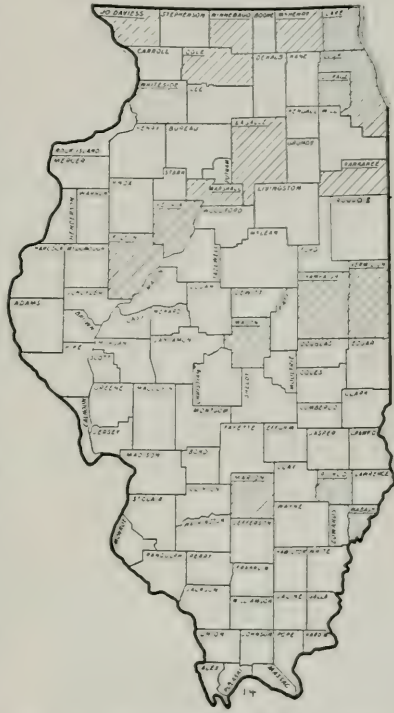


FIG. 14. Distribution of the Poplar.

POPULUS HETEROPHYLLA LINNAEUS

Swamp Cottonwood

Black Cottonwood

The Swamp Cottonwood is a small tree, with a few irregularly arranged, large limbs which form a narrow, open, round-topped crown. The thin, firm leaves, which are at first densely hairy but later become dark-green and smooth above and paler and woolly beneath, are broadly

ovate, with rather obtuse points, round or heart-shaped bases, and finely toothed margins. The stout, densely flowered staminate catkins, which appear in April or May, are about 2 or $2\frac{1}{2}$ inches long, while the broad, few-flowered pistillate catkins, which occur on other trees, are from 1 to 2 inches long. The fruits, thick-walled, long stalked, reddish-brown capsules about $\frac{1}{4}$ inch long, open in May, when the leaves are about half grown, and set free the minute, dark-brown, white-hairy seeds. The twigs are stout and, though at first velvety, soon become lustrous; and their angled pith is a conspicuous orange. The flower and leaf buds are distinct, the ovate, sharply pointed, reddish-brown leaf buds, which are covered by 4 to 7 slightly hairy scales, being about $\frac{1}{4}$ inch long, and the flower buds, though otherwise quite similar, about $\frac{1}{2}$ inch long. The straight, tapering trunk,

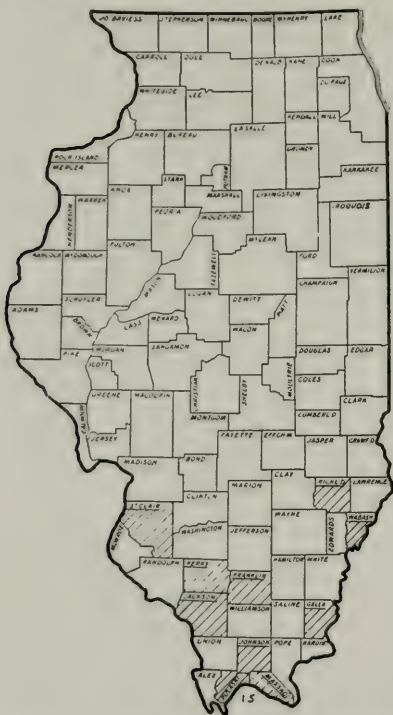


FIG. 15. Distribution of the Swamp Cottonwood.

which at maturity is covered by light reddish-brown, thick bark roughened by narrow, shallow fissures and long, narrow, flat ridges, rarely attains a diameter of 12 inches; and the height of the tree usually is from 25 to 40 feet.

Distribution: The natural range of the Swamp Cottonwood extends from Connecticut southward to Georgia and Florida, westward along the Gulf to Louisiana, and northward again along the Mississippi Valley into Michigan. In Illinois, it is a distinctly southern tree, for it extends northward only to Richland County in the east and to St. Clair County in the



PLATE 10

POPULUS HETEROPHYLLA LINNAEUS

SWAMP COTTONWOOD

west. It is a lover of low, rich lands subject to the overflow of rivers and makes its best growth on the flood plains of the Mississippi and in the valleys of the Big Muddy, the Cache, and the Little Wabash rivers.

According to Ridgway, it occurs with the Black Willow on the borders of swamps and attains a height of 90 feet and a diameter of $2\frac{1}{4}$ feet in the Wabash Valley.

Uses: The dull-brown heartwood and the thin, pale-brown sapwood of the Swamp Cottonwood are close-grained, soft, and weak, and have little commercial value. In Arkansas and Missouri, however, the tree is cut and sawed; and the lumber derived from it, known in the lumber trade as "black poplar" and "black cottonwood," is used in the interior finishing of houses. In Union and Alexander Counties, where the Swamp Cottonwood is cut, along with other swamp inhabiting trees, its lumber is sold, chiefly in the Cairo market, for use in the manufacture of box boards and egg crates; and in this region, natural stands are capable of yielding over 7,500 board feet per acre.

POPULUS BALSAMIFERA LINNAEUS

Cottonwood

The Cottonwood is a large tree, with a narrow, open, irregular crown made up of a few massive, erect branches which are bushy at the ends. The dark-green, lustrous leaves, which are thin and firm, from 3 to 6 inches long and about half as broad, very sharply pointed, and rounded or heart-shaped at the base, have finely toothed margins and long, slender, round petioles; and there are 2 glands on the leaf blade at its union with the petiole. The pendulous, densely flowered catkins, which appear in April and May before the leaves, are hairy, cylindrical structures from $2\frac{1}{2}$ to 4 inches long. The pistillate catkins, which mature in late May or June, bear a considerable number of rather closely placed, oval, pointed, brown capsules, which open by 2 opposite seams and set free the minute, pale-brown, white-haired seeds. The stout, lustrous twigs, at first bright reddish-brown, finally become yellowish and often angular. The sharply pointed, gummy buds, which are $\frac{1}{2}$ to 1 inch long, are rather divergent from the twig and are covered by dark-red scales. The trunk, which is covered by dark, red-tinted, gray, thick bark that is roughened by narrow fissures and broad, scaly ridges, attains a diameter of 1 to 3 feet; and the height of the tree is from 60 to 70 feet.

Distribution: The Cottonwood is rather widely distributed over the northeastern part of the United States, but it is everywhere a rare and local tree. In Illinois, it is found here and there through the length and breadth of the State, in small groups on rich, moist river banks and bottomlands.

Uses: The pale-brown heartwood and the thick, white sapwood of the Cottonwood are light and weak, soft and close-grained, and of little value, except that when mixed with the wood of other trees they serve in the manufacture of paper pulp. Cottonwood can be used also for excelsior; and when the tree is large, it can be made into match stock. Although the wood is tougher than that of the Aspen, it does not make a desirable fuel.

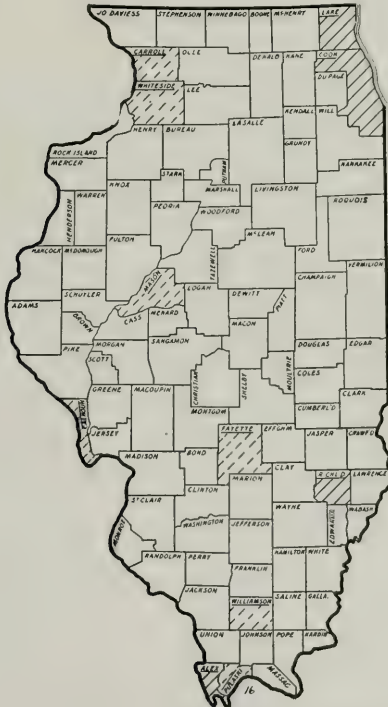


FIG. 16. Distribution of the Cottonwood.



PLATE 11

VIRGINIA COTTONWOOD

POPULUS BALSAMIFERA VIRGINIANA SARGENT

in Whiteside County, Virginia Cottonwood is found with Soft Maple, Elm, Willow, River Birch, Pin Oak, and Ash, where it forms a growth per acre of 88 trees over 6 inches in diameter and yields 18 cords per acre. The tallest tree in this region measured 80 feet in height. To the south, this tree grows, with the Swamp Cottonwood, along the levees of the Mississippi River in Union and Alexander counties, where it often is mixed with maples, gums, Sycamore, Elm, and Willow, though the stand at times may be almost pure.

Uses: The wood derived from the Virginia Cottonwood is light and soft as well as weak and fine-grained, but tough. The heartwood is dark-brown, and the sapwood is thick and nearly white. In the main, it is used for manufacturing pulp and packing cases and for light fuel. The lumber is hard to season, due to a tendency of the wood to warp excessively, and though easily worked and finished, it often has a "woolly" texture when planed. It is especially valuable for crating uncanned foods, for besides making a strong container it does not impart a woody taste or odor to the foods. As a result, the trees that are cut in Union and Alexander counties are used mainly in the manufacture of egg crates, baskets, berry boxes, and the like. Because of its toughness, it is used also in three-ply veneer, from which trunks, musical instruments, and furniture drawers are made; but it is most acceptable for wagon boxes, scoop-boards, barn floors, the lining of refrigerator cars, and for bridge floors, in all of which its toughness is its main asset. Its minor uses include pyrography, where its whiteness is of value, and the manufacture of excelsior and slack cooperage, that is, the staves and heads of barrels. Grown on the Mississippi, Ohio, and Illinois rivers, trees of this variety are being cut into logs, or "bolts," $4\frac{1}{2}$ feet long with a minimum diameter of 3 inches, and are sold in Ohio for pulpwood.

Because of its softness, this is one of the few woods not acceptable for railroad ties, but it provides serviceable fence posts when treated with coal-tar creosote against decay.

In southern Illinois, this tree grows very rapidly, for there the overflowed land and the rich, alluvial soil afford its ideal conditions; but even on sand it will make a fair growth. Its seeds require abundant sunlight and moisture for germination; and it proves a useful tree for planting on "blow sand" and in eroded regions. But, being intolerant of shade, the stand rapidly thins out as it grows; and at maturity there may not be over 80 or 90 good-sized trees to the acre.

OTHER POPLARS IN ILLINOIS

Populus tacamahacca Miller, the Tacamahac, is possibly not native to Illinois, though numerous collections have been so reported. *Populus canadensis* Muenchhausen, which is believed to be a hybrid between *P. balsamifera* and *P. nigra*, is best known by the variety *Eugenie* Schelle, the Carolina Poplar of the American nurseries. It occasionally escapes from cultivation. The Balm of Gilead, *Populus candicans* Aiton, is reported by Pepoon¹ near the shore of Lake Michigan in the vicinity of Montrose Boulevard and northward; and the Lombardy Poplar, *Populus nigra Italica* du Roi, is also reported by Pepoon¹ as having been "originally abundant near Lake Michigan for one-fourth of a mile north of Wilson Ave."

SALIX LINNAEUS

The Willows

Family SALICACEAE

Deciduous trees or shrubs, with broad- or narrow-bladed, feather-veined, alternately arranged leaves. Flowers in sessile or stalked catkins placed laterally or terminally on leafy branches; pistillate and staminate catkins on separate trees, appearing before the leaves; each flower with a small, gland-like disk. Twigs slender and round, with small and round white pith. Buds mostly small, sessile, appressed, covered by a single exposed scale. Fruit a small, sharply pointed, one-celled capsule, which separates at maturity into 2 recurved parts.

There are between 160 and 170 species of *Salix*, and the range of the genus extends from the Arctic region southward to Brazil and Chili in the Americas, and to Madagascar, southern Africa, the Malay Peninsula, Java, and Sumatra. About 70 species attain tree size; and of this number, 24 occur in North America and 2 in Illinois.

KEY TO THE ILLINOIS WILLOWS

- Leaves narrow ($\frac{1}{4}$ - $\frac{3}{4}$ inch wide), green on both sides; petioles short;
twigs dark green.....*S. nigra* p. 60
Leaves broader ($\frac{5}{8}$ -1 $\frac{1}{4}$ inches), whitened beneath; petioles longer
($\frac{1}{4}$ - $\frac{1}{2}$ inch); twigs yellowish.....*S. amygdaloides* p. 62

¹ Flora of the Chicago Region, pp. 272-273.

SALIX NIGRA MARSHALL

Black Willow

The Black Willow usually is a small tree, with a broad, open crown of stout, ascending branches that droop at the ends. The thin, light-green, and lustrous leaves, 3 to 6 inches long by $\frac{1}{8}$ to $\frac{3}{4}$ inch wide, have long, attenuated tips, rounded or wedge-shaped bases, and finely toothed



FIG. 18. Distribution of the Black Willow.

margins. The petioles are short and straight. Narrow, cylindrical catkins, 1 to 3 inches long, appear in May on the ends of short leafy branches, the pistillate catkins maturing smooth, reddish-brown capsules about $\frac{1}{8}$ inch long, which contain the minute, white-hairy seeds. The slender, reddish-brown to pale-orange twigs are brittle at the base and have no end bud; but the sharply pointed lateral buds are about $\frac{1}{16}$ to $\frac{1}{8}$ inch long and are covered by one reddish-brown scale. The trunk, which occasionally attains a diameter of 2 or 3 feet, is covered by thick, brown or nearly black bark deeply furrowed into narrow, connected ridges. The height of the tree usually is from 30 to 40 feet.

Distribution: The Black Willow ranges from southern New Brunswick westward to the north of Lake Superior and southward to Georgia in the East and Texas in the West. It is a tree of low, alluvial ground, and occurs in such situations throughout Illinois. It is particularly prevalent along the course of the Mississippi, and increases in size and abundance toward the south.

Uses: The fine-grained, soft wood of the Black Willow, pale reddish-brown in the heart and nearly white in the sapwood, is light and weak and yields only a low grade of lumber, suitable in the main for crates and boxes, because of its toughness and pleasant odor. But a fine grade of charcoal is obtained from it, which is particularly in demand for medicinal and chemical purposes, especially the manufacture of gun powder. The wood is suitable also for paper pulp; and the tree is now cut on the



PLATE 12

SALIX NIGRA MARSHALL

BLACK WILLOW

islands and shores of the Mississippi, the Illinois, and the Ohio River up to Shawneetown and delivered by barge to the markets, where it is purchased at a fair price by an Ohio pulp manufacturer. For this use, the willow logs must be sound and must be at least 3 inches in diameter at the small end.

The Black Willow also has an important agricultural use, for the cuttings sprout readily and grow rapidly, and when they are planted in eroded gullies and along stream banks they successfully combat the destructive action of water.

SALIX AMYGDALOIDES ANDERSSON

Peach Willow

Almond Willow

The Peach Willow is a rather tall tree, with a narrow, rounded head of straight, up-tilted branches. The broad and firm but thin leaves are green and lustrous above but whitened with bloom beneath, and they have long, slender points, rounded or wedge-shaped bases, and finely toothed edges.

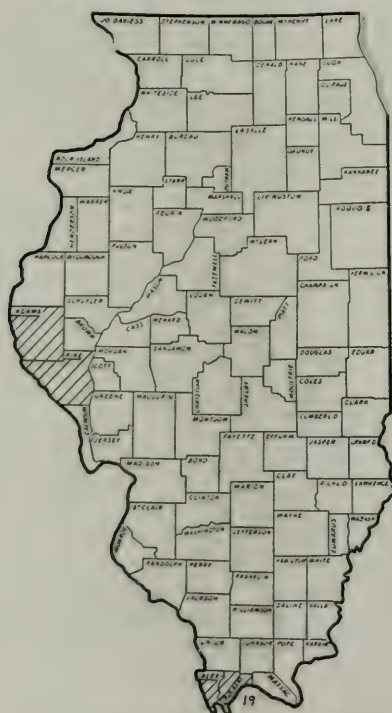


FIG. 19. Distribution of the Peach Willow.

Their slender petioles are round, $\frac{1}{4}$ to $\frac{1}{2}$ inch long, and usually twisted. The catkins, which are long and erect, appear in May with the leaves; and the pistillate catkins bear at maturity a considerable number of short-stalked, yellowish, conical capsules $\frac{1}{4}$ inch long, which open along 2 seams to liberate the tiny, hairy seeds. The slender, yellowish twigs, which are not brittle at the base, are smooth or rarely a little hairy and are marked with scattered, pale lenticels. There is no end bud. The lateral buds are about $\frac{1}{8}$ inch long, rather blunt, and are inclosed in one shiny brown scale. The trunk, which extends high into the crown, attains a diameter of 1 to 2 feet; and the brown bark with which it is covered is divided by fissures into flat, connected ridges. The tree customarily attains a height of 60 to 70 feet.



PLATE 13

SALIX AMYGDALOIDES ANDERSSON

PEACH WILLOW

Distribution: The Peach Willow, sometimes called the Almond Willow, is a tree of stream banks. It ranges from Montreal westward into Oregon and Washington and southwestward into Texas. In Illinois, it is confined to the southwestern section of the State, with the exception of Adams and Pike counties.

Uses: The close-grained, weak wood of the Peach Willow, which is light-brown in the heart and white in the thick sapwood, is soft and inferior and is only occasionally sawed into cheap lumber. But it furnishes a good source of charcoal and is cut in Illinois for the same purposes as the wood of the Black Willow.

JUGLANS LINNAEUS

The Walnuts

Family JUGLANDACEAE

Large, deciduous trees, with very large, alternate leaves divided into a number of leaflets arranged in pairs at intervals on the petiole, which is tipped by a single leaflet. Flowers of two kinds, both produced by the same tree; the staminate flowers in catkins; the pistillate flowers solitary or in clusters. Fruit consisting of a pulpy husk and, within it, a globose, roughly fissured, hard, and thick-walled nut. Twigs stout and more or less fluted, their brown and angular pith chambered by thin plates, their large end buds covered by 2 pairs of opposite scales, and their blunt and somewhat flattened axillary buds standing above large, 3-lobed leaf scars.

The 11 species of this genus are widely distributed in the temperate and subtropical regions of North and South America, in China, Japan, and Formosa. Of the 6 North American species, 2 are natives of Illinois.

KEY TO THE ILLINOIS WALNUTS

- Leaflets 7-19; twig-pith dark-brown; terminal bud elongated; leaf-scars hairy at the upper edge; husk and nut much longer than wide; bark gray, with smooth ridges.....**J. cinerea** p. 65
- Leaflets 11-23; twig-pith light-brown; terminal bud globular; leaf-scars without hairs; husk and nut nearly spherical; bark dark-brown, with rough ridges**J. nigra** p. 68

Butternut

The Butternut, called also *White Walnut*, is a tree of moderate size, with a trunk that divides into several stout limbs which spread horizontally and form a broad and symmetrical, round-topped crown. The compound leaves, which are 15 to 30 inches long, are made up of from 6 to 18 nearly sessile leaflets arranged in pairs (not necessarily opposite) along the stout, hairy petiole and a single terminal, long-stalked leaflet. The leaflets themselves are 3 to 4 inches long by 1½ to 2 inches wide, their blades unequally expanded on the two sides of the main nerve, the upper face yellow-green and wrinkled, and the lower face pale and covered with soft hairs. The pendulous, cylindrical staminate catkins grow from lateral buds on year-old twigs, and the pistillate flowers, which are about ⅓ inch long and without a stalk, are found in spikes of 6 to 8 flowers at the tip of the new growth. Both kinds of flowers are borne on the same branchlet, usually near each other. The fruit, an ellipsoid, 4-ridged, roughly corrugated, pointed nut, lies within an indehiscent, green, pulpy husk covered with glandular hairs. The stout, lustrous twigs, at first greenish but becoming reddish-or orange-brown, have dark-brown pith divided by firm diaphragms and carry small, blunt, lateral buds often superposed above the hair-fringed tops of the 3-lobed leaf scars. The terminal bud is ½ to ⅔ inch long and very bluntly pointed. The short, stout trunk, which is clothed by a thin, light-gray bark fissured into broad, scaly ridges, attains a diameter of 1 or 2 feet and usually divides at a height of 15 to 20 feet, but under good conditions often forms a tall, straight bole with very little taper. The tree is usually 30 to 50 feet high, but it may attain a height of 100 feet.



FIG. 20. Distribution of the Butternut.



PLATE 14

JUGLANS CINEREA LINNAEUS

BUTTERNUT

Distribution: The Butternut has a range that extends from New Brunswick, in eastern Canada, westward into Minnesota and southward into Georgia and Arkansas. It is found throughout Illinois, in the rich, moist soils of ravines and on drier and poorer hilly ground along streams. In the northern counties, in which it is not encountered frequently, it occurs in small, scattered, and often isolated groups; but in the southern counties, which are nearer the center of its distribution in Kentucky and Tennessee, it is common and even conspicuous in the ravines. It is reported by Pepon¹, however, as "common along the north branch of the Chicago River and in the Niles Woods," as well as "along the Des Plaines Valley from Riverside northward." The Butternut forms no distinct forest type, for the individual trees are scattered and are never dominant; but it is associated with the Tulip Tree, Bass Wood, Black Cherry, Black Gum, and the Beech in the ravines and bottomland, and with oaks and hickories on the uplands.

Uses: The light, rather coarse-grained wood of the Butternut is soft and weak, but it is easily worked and polished. The heartwood is light-brown and darkens with exposure, and the sapwood is thin and light-colored. Although the tree is not an important source of timber, its lumber is used occasionally for the interior finishing of houses and also for the lining of furniture drawers and cabinets. The husks of the nuts, when they are boiled, yield a yellow or brownish dye which is used now for dyeing carpets and rugs and was employed by the pioneers for coloring cloth. The brown color so obtained is called "butternut." The oily and nutritious nuts are highly prized in their wild state, and Colby² says that "promising varieties originating in the East, such as the Manchester, should be tried out under our conditions."

¹ Flora of the Chicago Region, p. 274.

² Trans. Ill. St. Acad. Sci. Vol. 18, p. 142. 1925.

JUGLANS NIGRA LINNAEUS

Black Walnut

The Black Walnut is a large, high tree, with a straight and continuous trunk which gradually breaks up, as it ascends, into stout, spreading limbs to form a round-topped crown. The large, compound leaves, which are from 1 to 3 feet long, are made up of 10 to 22 very short-stalked leaf-

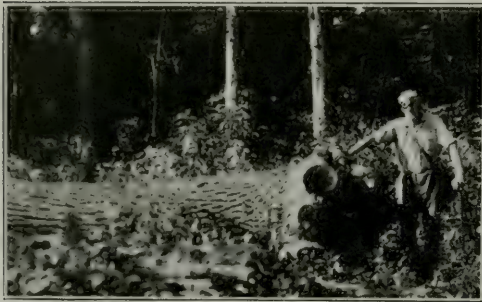


FIG. 21. Black Walnut cut at Allendale. In felling Walnut, no stump is left, for the veneer obtained from the base of the trunk is beautifully figured.

lets set in pairs along the hairy petioles and one long-stalked leaflet at the end. The stout, unbranched catkins, 3 to 5 inches long, which bear the staminate flowers, are found on the one-year-old growth; and the sessile pistillate flowers, $\frac{1}{4}$ inch long, are in 2- to 5-flowered spikes at the end of the new growth. Both kinds occur on the same branchlet. The fruit is a spherical, slightly flattened, hard-

very rough-shelled nut, 1 to $1\frac{1}{2}$ inches in diameter, borne in a thick, indehiscent, pulpy husk covered with clusters of pale hairs. The stout, orange-brown, soft-hairy twigs, which eventually become light-brown, have their pith cavities divided into numerous small chambers by persistent, pithy partitions. The nearly spherical, pale-gray terminal bud, $\frac{1}{3}$ inch long, is covered by 2 pairs of scales, the outer pair lobed and the inner pair somewhat divided at their tips. The lateral buds are smaller and stand, often superposed, above a notch in the somewhat 3-lobed and hairless leaf scar. The trunk, which usually attains a diameter of 2 to 3 feet, is clothed by dark-brown to blackish bark 2 or 3 inches thick, which is divided by deep fissures into broad, scaly-topped, rounded ridges. The tree usually attains a height of 75 to 100 feet, but it is sometimes 150 feet high and 5 to 6 feet in diameter at the trunk.

Distribution: The Black Walnut is an inhabitant of rich bottom-lands and hillsides from Massachusetts westward to Minnesota and southward to Florida and Texas. In Illinois, it grows in suitable situations throughout the length and breadth of the State, but it is found in pure stands only occasionally, in small areas where the soil and moisture con-



PLATE 15

JUGLANS NIGRA LINNAEUS

BLACK WALNUT

ditions are particularly favorable. Usually it grows in company with such trees as the ashes and hickories, the Tulip Tree, Red Gum, Hackberry, and Honey Locust.

Uses: The heavy, hard, coarse-grained, rich-brown wood of the Black Walnut, with its thin, pale sapwood, is not only strong and durable but also easily worked and capable of being highly and beautifully polished. As a consequence, the Black Walnut is one of the most valuable of our timber trees. It is in great demand in the manufacture of furniture, gunstocks, steering wheels, and automobile wheel spokes, and during the World War it was one of the woods used in airplane propellers. For wood carving, it always has been our finest native stock. At the present time, the greatest demand is for logs 16 inches or more in diameter, which can be sawed into veneer.

Trees that have been grown rapidly in small groups furnish veneer wood with striking figures, which is used extensively in the finishing of organs, pianos, and cabinet articles such as desks, as well as for panels in the interior decoration of houses. Between 50 and 60 years ago, the

Black Walnut trees in the Wabash Valley, many of which were 125 feet high, with a clear bole 50 feet long and 15 feet around, were grubbed out, instead of being cut as they are now, in order to obtain lumber bearing the fantastic patterns formed by the contorted grain of the wood where the roots and trunk join. Native trees sometimes bear large deformities on their trunks, to which has been given the name "burl"; and these structures are so much in demand that they can be sold by the pound, for they furnish a pattern-grained veneer which, when carefully matched, produces decorative effects very similar to the expensive, imported Circassian walnut.

The consumption of walnut lumber in Illinois is very large, and the price which the logs will bring at the mill, given by Chapman and Miller¹ as \$85 per thousand board feet in 1920, is the highest of any Illinois

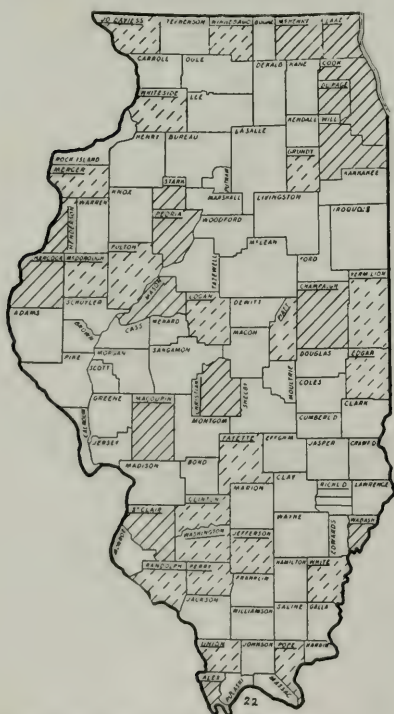


FIG. 22. Distribution of the Black Walnut.

¹ Nat. Hist. Surv. Bul. Vol. 15, p. 143. 1924

woods. In 1925, Illinois sawmills produced 4,589,000 board feet of walnut lumber. According to W. D. Brush², there were approximately 79 million board feet of walnut in our standing trees in 1920, though Missouri had at the same time some 107 million board feet.

Although it is not suited to sandy, gravelly, poorly drained, or thin soils, the Black Walnut thrives on good, deep, well-drained, clayey or loamy soils. A plantation in Pope county, near Rose Bud, situated on a yellow silt-loam soil of poor quality, has not made a satisfactory growth; but in the rich lands along the Mississippi and in flat valleys of many secondary streams it grows well, requiring about 36 years to attain the minimum 10-inch sawlog size, while other trees under the same conditions require from 42 to 86 years.

The bark and nut-husks of the Black Walnut yield a yellow dye; and the oily and nutritious nuts, collected and prized for their flavor, are used commercially in candies, cakes, and salads. It is also possible to secure nuts of more commercial value by "top-working," that is, grafting the tops of the native trees with the improved varieties (which may also be planted), such as the Stabler, the Ohio, and the Thomas, which have more easily cracked nutshells and larger kernels.

CARYA NUTTALL

The Hickories

Family JUGLANDACEAE

Moderate to large, deciduous trees, with large, alternate, compound leaves composed of an odd number of toothed leaflets disposed in pairs along the petiole, which is terminated by the odd leaflet. Staminate and pistillate flowers separate; the former in slender catkins borne, 3 together, on the 1-year-old wood; the latter in 2- to 10-flowered spikes at the end of the new growth; both kinds on the same tree and usually on the same branchlets. Fruit a globose to oblong, thick and tough or thin and brittle, hard-shelled nut with 2 or 4 more or less evident seams, borne in a globose to pear-shaped, woody husk that splits into 4 parts.

Excepting a single species, which has a restricted range in China, *Carya* is confined to the eastern part of the North American Continent, where 17 species are known, 15 of which occur in the eastern part of the United States. Our present-day hickories are remnants of a much larger group, which was distributed during ancient geological times over much of North America, Europe, Northern Africa, and possibly Asia. Except in North America, the hickories were exterminated during the Ice Age;

² U. S. Dept. Agric. Bul. 109. 1921.

and some of the species, such as the White Hickory, the Water Hickory, and the Shagbark, now present in Illinois, are known, by fossils taken from ancient clay deposits and river terraces, to have lived in the Pleistocene epoch of the Quaternary Period.

There are, at the present time, 8 species of *Carya* in Illinois. As some of the species are variable, they have been divided into several varieties, which, if considered as distinct trees, raise the number of Illinois hickories to 16. As the varieties are difficult to identify, only the species are given in the key.

KEY TO THE ILLINOIS HICKORIES

- Buds with opposite scales; leaflets generally curved backwards; nut husks usually winged.
- Leaflets 9 to 17; catkins short-stalked; nuts elongated, with sweet meat *C. pecan* p. 73
- Leaflets fewer; catkins long-stalked; nuts globose to oval, with bitter meat.
- Leaves 6 to 10 inches long; leaflets 5 to 9; nut husk 4-winged in its upper half; nut gray..... *C. cordiformis* p. 77
- Leaves 9 to 15 inches long; leaflets 7 to 13; nut husk 4-winged from top to base; nut brown to black..... *C. aquatica* p. 80
- Bud scales not in pairs; leaflets not recurved; nut husks usually wingless, meat sweet.
- Terminal buds $\frac{1}{2}$ to 1 inch long; branchlets stout; twigs hairy; nut husks thick.
- Leaflets 5; leaves 8 to 14 inches long; nut nearly white, compressed, more or less 4-ridged..... *C. ovata* p. 81
- Leaflets usually 7, but sometimes 5 or 9.
- Leaves 15-22 inches long; nuts yellow to reddish-brown, somewhat compressed, 4- or 6-ridged..... *C. laciniata* p. 83
- Leaves 8-12 inches long; nuts reddish-brown, more or less compressed and 4-ridged..... *C. alba* p. 86
- Terminal buds not over $\frac{1}{2}$ inch long; branchlets slender; twigs smooth; nut husks thin.
- Leaflets usually 5; leaves 8 to 12 inches long; nut obovate, compressed, not ridged; shell thick and hard..... *C. glabra* p. 88
- Leaflets usually 7, rarely 5.
- Leaves 6-10 inches long; nut pale, ridged in the upper half; shell thin *C. ovalis* p. 90
- Leaves 8-12 inches long; nut dark reddish-brown, 4-angled in the upper, or in both halves; shell thin, conspicuously reticulate-veined *C. Buckleyi* p. 93



PLATE 16

CARYA PECAN ASCHERSON & GREENE

PECAN

the bottomlands of the Mississippi, the Big Muddy, the Kaskaskia, the Ohio and the Wabash rivers, extending up the Wabash to Wabash County.

On the bottomlands of the Illinois River in Mason County, the Pecan is found in association with the Pin, Red, and Burr oaks, the River Birch, Black Walnut, Persimmon, Shagbark Hickory, Elm, Soft Maple, Honey Locust, Ash, and Cottonwood; and in the Kaskaskia bottomlands of Washington County, it grows with Black and White oaks, hickories, Soft Maple, Elm, Ash, Sassafras, River Birch, Sycamore, Black Walnut, Hackberry, and Honey Locust. In the bottomlands of Union County, Pecan is found in company with Soft Maple, Elm, Ash, Box Elder, willows, and Pin Oak.

According to Pepoon¹, the Pecan grows just within the southern limit of Jo Daviess County; and in the course of our forest survey, it was found also in the Mississippi bottoms of Whiteside County. In this part of the State, it is associated with Soft Maple, Elm, Pin Oak, Ash, and River Birch.

On the islands of the Illinois River, below Hardin, in Calhoun County, the Pecan has been left standing, for the sake of its nuts, though the other hardwoods have been cut for charcoal; and on the bottoms of the Mississippi and Big Muddy, trees are allowed to stand in the fields and along the levees, for the same reason.

In the lower Wabash Valley, Ridgway observes that the Pecan "is the most symmetrical and majestic of all the trees, and the largest of the hickories." Ten trees measured by our survey party ranged from 75 to 95 feet high, with trunk diameters, taken at breast height, of from 16 to 26 inches. The trunks of the trees are long and straight, occasionally extending clear for 80 or 90 feet to the first limb, and bearing a large head with a spread of 100 feet or more. Ridgway reports a very large Pecan 170 feet high with a trunk, clear for 90 feet, measuring 16 feet in circumference.

Uses: The heavy, coarse-grained wood of the Pecan, the heart a light red-tinted brown and the thin sapwood a light brown, is hard but brittle and weak. It has little commercial value, being used mainly as fuel and occasionally for tool handles and for the wooden parts of farming implements. In southern Illinois, Pecan logs are cut into veneer, from which the rims of bushel baskets are made.

The tree's greatest value, however, lies in the nuts it produces. In the Wabash Valley, the average wild tree yields annually about 15 pounds of nuts, which are sold at a price of 17 to 25 cents a pound. Although

¹ Trans. Ill. St. Acad. Sci. Vol. 3, p. 155. 1910.

the tree grows well in northern Illinois, it can not be depended upon to produce an annual crop north of the 39th parallel, which corresponds closely to a line drawn from the mouth of the Illinois River eastward to Robinson. There are, besides the native tree, several excellent varieties such as the Niblack, Busseron, and Posey, which can be grown in our southern counties.

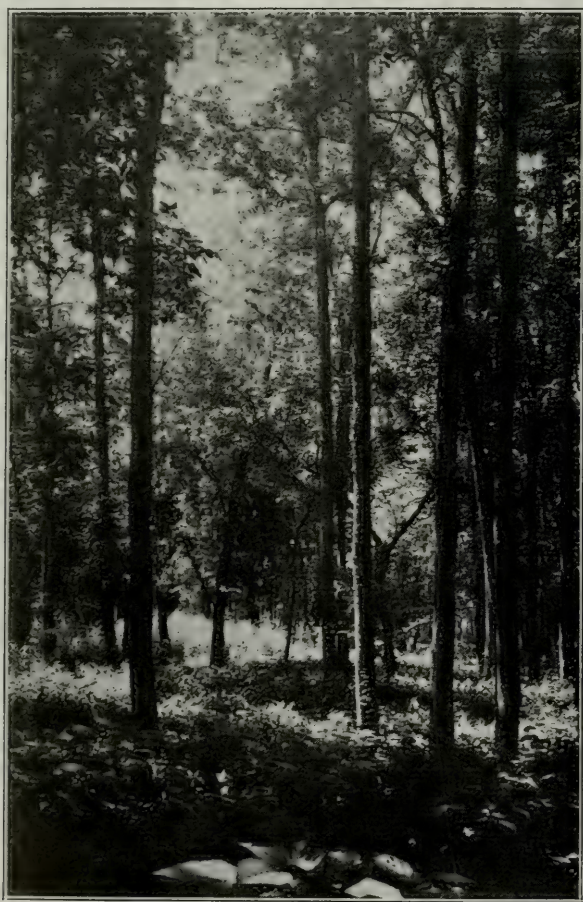


FIG. 24. Forest-grown Pecan ten miles north of Shawneetown.

CARYA CORDIFORMIS K. KOCH

Pignut

Bitternut

The Pignut is a moderate to large tree, with stout, ascending branches which form a rounded and broad-topped crown. The alternate, compound leaves, usually 6 to 10 inches long, consist of 7 or 9 firm, coarsely toothed leaflets, one set apically on the end and the others sessile in pairs along the petiole. The leaflets, which

are 4 to 6 inches long by $\frac{3}{4}$ to $1\frac{1}{4}$ inches wide, are dark-green and smooth on top but paler and hairy, at least on the midrib, beneath. The

staminate catkins, which are 3 to 4 inches long, are borne 3 together on a long stalk on the 1-year-old growth; and the pistillate flowers are found, 1 or 2 together, at the end of the new growth. The globose to oblong husk

of the nut, $\frac{3}{4}$ to $1\frac{1}{2}$ inches long, is thin and a little hairy and bears 4 wings, which extend from the tip about to the middle; and the oval to oblong, reddish-gray or brown nut,

which is marked between and along the seams with dark lines, has a thin, brittle shell, within which is a bright-brown, very bitter seed. The glossy, rather slender twigs, which are often hairy and covered with yellow glands at the tip, become at length light-gray

and contain angular, brown piths. The yellowish, blunt terminal bud, $\frac{1}{3}$ to $\frac{3}{4}$ inch long, is inclosed by 4 paired scales; and the smaller lateral buds, $\frac{1}{8}$ to $\frac{3}{4}$ inch long, stand superposed above the large, shield-shaped leaf-scars, which are marked by 3 groups of bundle-traces. The trunk, which is covered by thin, light-gray bark with shallow fissures and narrow, flaked ridges, attains a diameter of 1 to $2\frac{1}{2}$ feet; and the tree becomes 40 to 75, and exceptionally 100, feet high.

The yellowish, blunt terminal bud, $\frac{1}{3}$ to $\frac{3}{4}$ inch long, is inclosed by 4 paired scales; and the smaller lateral buds, $\frac{1}{8}$ to $\frac{3}{4}$ inch long, stand superposed above the large, shield-shaped leaf-scars, which are marked by 3 groups of bundle-traces. The trunk, which is covered by thin, light-gray bark with shallow fissures and narrow, flaked ridges, attains a diameter of 1 to $2\frac{1}{2}$ feet; and the tree becomes 40 to 75, and exceptionally 100, feet high.

Distribution: The Pignut, a tree of wet, low stream banks and swamps, ranges from Maine westward through Canada into Minnesota



FIG. 25. Distribution of the Pignut.



PLATE 17

CARYA CORDIFORMIS K. KOCH

PIGNUT



PLATE 18

CARYA AQUATICA NUTTALL

WATER HICKORY

and southward into Florida and Texas. It is to be found throughout Illinois, growing along streams and on rich bottomlands, together with elm, the White, Red, and Pin oaks, the White Ash, and the Shagbark and Big Shellbark hickories. In Wabash County, it is associated with the Shagbark and the Pignut Hickory. Three trees between 93 and 106 years old, which stand on a deep, gray, silt-loam soil near Benton, in Franklin County, are from 64 to 83 feet high and 16 to 22 inches in diameter.

Uses: The strong, close-grained wood of the Pignut, dark-brown in the heart and pale or nearly white in the sapwood, is heavy, tough, and elastic. It is used in the manufacture of wagon and automobile wheels, for wagon-tongues, whipple-trees, and tool handles, as well as for hoops and for fuel. The tree, which is a valuable timber species, furnishes a part of the hickory lumber of commerce. In Illinois, its commercial range is co-extensive with its botanical range, except for a small region, which includes the southern tip of the State.

CARYA AQUATICA NUTTALL

Water Hickory

The Water Hickory is a moderately large tree, with a narrow head of slender, up-tilted branches. Its alternate, compound leaves, usually from 9 to 15 inches long, are made up of from 7 to 13 long-pointed, falcate leaflets 3 to 5 inches long by $\frac{1}{2}$ to $1\frac{1}{2}$ inches wide, one standing at the end, and the others, sessile or somewhat stalked, in pairs along the slender, dark-red, hairy petioles. These leaflets are thin and dark-green above but brownish beneath. The staminate catkins hang in 3's, from a definite stalk, toward the end of the one-year-old growth; and the pistillate flowers are in spikes at the tip of the new growth. The conspicuously 4-winged husk, $1\frac{1}{2}$ inches long by 1 to $1\frac{1}{4}$ inches wide, is dark-brown, with a thick sprinkle of bright yellow scales. Within it is the 4-angled and 4-ribbed, dark reddish-brown nut, the thin shell of which is very irregularly wrinkled lengthwise. The dark-brown seed is very bitter. The slender twigs, at first brownish or gray and woolly but later gray and usually smooth, are marked by numerous lenticels. The terminal bud, which often is hairy, measures $\frac{1}{8}$ to $\frac{1}{4}$ inch in length; and the sharply pointed, reddish-brown lateral buds stand above small, oval leaf-scars. The trunk, which rarely attains a diameter of 2 feet, is clothed in thin, red-tinted bark which separates into long, loose scales. The tree occasionally attains a height of 80, or even 100, feet.

Distribution: The Water Hickory, an inhabitant of swamps subject

to inundation by rivers, ranges from Virginia south to Florida, west to Texas, and north again along the Mississippi to southern Illinois. E. J. Palmer, of the Arnold Arboretum, has collected specimens in Massac County, and C. J. Telford, of our staff, has found the tree in Pulaski County along the Cache River, where it grows with the Pumpkin Ash, Cow Oak, Hackberry, Sycamore, and Red Gum.

Uses: The heavy, close-grained wood of the Water Hickory, brown in the heartwood and nearly white in the sapwood, is strong but rather brittle. Other than for fencing and fuel, it has few uses; and its rarity in Illinois places it among our non-commercial species.

CARYA OVATA K. KOCH

Shellbark Hickory

Shagbark Hickory

The Shagbark Hickory is a moderately large tree, with a high and narrow crown of long, stout, ascending limbs. Its leaves, 8 to 14 inches long, are made up of 5 or 7 finely toothed leaflets sessile in pairs along the stout, grooved petiole, with the odd leaflet short-stalked and terminal. The leaflets, which are sharp-pointed and ciliate on the margins, measure 5 to 7 by 2 to 3 inches. They are thin but firm, dark-green and smooth above, and pale and often hairy beneath. The staminate catkins, in groups of 3 on long stalks, are 4 or 5 inches long, and the 2- to 5-flowered pistillate spikes cap the new growth. The nearly globose, dark reddish-brown nut husk, 1 to 2½ inches long, holds a variously shaped, pale to nearly white, thin-shelled, more or less 4-ridged nut with an aromatic, sweet seed. The stout, reddish-brown or grayish twigs bear dark-brown, hairy terminal buds ½ to ¾ inch long. The white-woolly lateral buds, ⅓ to ½ inch long, stand above large, shield-shaped to oblong leaf-scars. The trunk, which is usually 2 to 3 feet in diameter, is covered by light-gray bark which separates into rough plates often a foot long and 6 or 8 inches wide, giving the "shaggy" appearance.

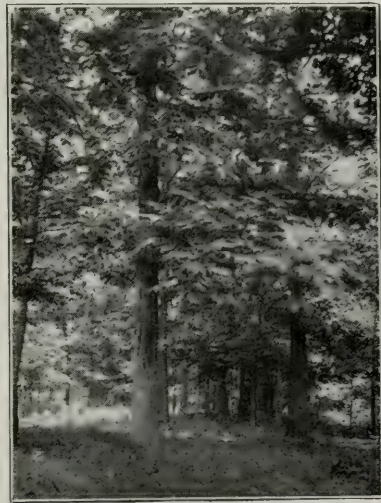


FIG. 26. Shagbark in the oak-hickory forest near West Frankfort.



PLATE 19

CARYA OVATA K. Koch

SHAGBARK HICKORY

Distribution: The Shagbark Hickory, found in rich, deep soil on low hills and near streams and swamps, ranges from Maine to Minnesota and south to Florida and Texas. It grows in suitable situations throughout the length and breadth of Illinois and is one of the chief trees of our oak-hickory forests, its most common associates being the White and Black oaks. In LaSalle and other northern counties, the Shagbark grows with White, Red, and Burr oaks, Elm, Maple, and other trees; in Champaign County it is found with Hard Maple, Buckeye, other hickories, Bass Wood, and Elm; and in Franklin County it is accompanied by the Post, White, and Burr oaks, Persimmon, Ash, and the Black and Sweet gums.

Uses: The strong, very hard, and heavy wood of the Shagbark, light-brown in the heart and nearly white in the sapwood, is tough, elastic, and close-grained. It is used in the manufacture of wagon and automobile wheels, farm implements, axe helvcs, and tool handles. Small trees, once used for barrel hoops, are now used to make rustic furniture. The wood has a high fuel value and is used by packing plants to prepare smoked meats.

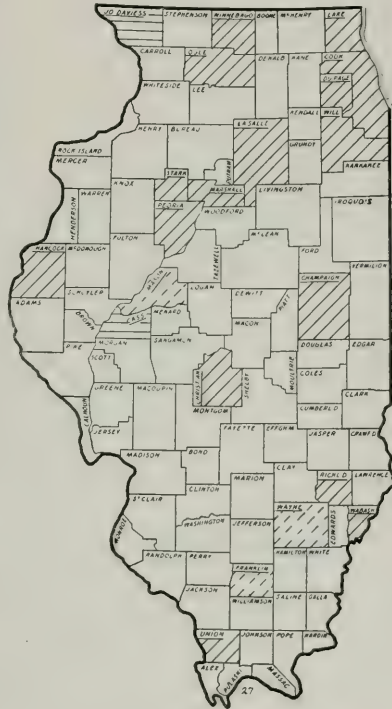


FIG. 27. Distribution of the Shagbark.

CARYA LACINIOSA SCHNEIDER

Big Shellbark

King Nut

The King Nut is a large tree, with short, spreading branches that form a narrow, oblong crown. The large, compound leaves, 15 to 22 inches long, are made up of 5, usually 7, or 9, sharply pointed and finely toothed leaflets 4 to 9 inches long by 3 to 5 inches wide, which are sessile and in pairs along the stout, somewhat flattened, and grooved petiole. The odd leaflet is narrowed into a short stalk. The leaflets are dark-green and lustrous above and pale and soft-hairy beneath. The staminate catkins, which are 5 to 8 inches long, hang in clusters of 3 from rather short, pen-



PLATE 20

CARYA LACINIOSA SCHNEIDER BIG SHELLBARK HICKORY.

dulous stalks, and the pistillate flowers form 2- to 5-flowered spikelets at the tip of the new growth. The more or less globose, woody nut-husks, which are roughened by orange-colored lenticels, are $1\frac{1}{4}$ to $2\frac{1}{2}$ inches in diameter and light-orange or dark chestnut-brown. The prominently 4- to 6-ridged, light-yellow to reddish-brown nuts, $1\frac{1}{4}$ to $2\frac{1}{2}$ inches in diameter, have hard, bony shells and chestnut-brown, sweet seeds. The stout, somewhat hairy twigs are roughened by orange lenticels and bear somewhat triangular leaf-scars, above whose indented upper margins stand the small lateral buds. The blunt, dark-brown terminal bud is sometimes 1 inch long. The trunk, which attains a diameter of 2 to 3 feet, bears a light-gray, shaggy bark. The height of the tree, usually from 50 to 90 feet, is occasionally 120 feet.



FIG. 28. Distribution of the Big Shellbark.

Distribution: The King Nut, usually a tree of rich bottomlands subject to the spring overflow of rivers, ranges from New York and Ontario westward into Iowa and Nebraska and southward in Louisiana. In Illinois, it is commonest in the south, but occurs as far north as Peoria County. It does not often form pure stands, but grows with other trees, among which are ordinarily the Elm, the White Ash, the White, Cow, and Overcup oaks and the Shagbark. In the Skillet Fork bottoms of Wayne County, however, the forestry survey discovered it in nearly pure stands, associated only with some Pin Oak, Soft Maple, Elm, and Shagbark. And in Logan County, it grows with Pin Oak, Soft Maple, and Ash.

Uses: The very hard, close-grained wood of the King Nut, which is not distinguished in the lumber trade from that of the Shagbark, is very flexible, heavy, and dark-brown, with a rather thin, whitened sapwood. Though not of more than medium strength, it is equal in toughness to other species, and is used for the same purposes as the wood of other hickories.

The nuts, which are larger than Shagbark nuts, though not so pleasantly flavored, are sold frequently on the market. Though hard to crack, they can be wetted and then dried by heat—a process which renders them easy to crack.

CARYA ALBA K. KOCH

Hickory

The tree commonly called Hickory, but known also as White Hickory and Mockernut, is of moderate size, with either a narrow, oblong crown of upright, rigid branches or a broad, round-topped crown of graceful, somewhat drooping branches. Its alternate, compound leaves,

8 to 12 inches long, have 5 or 7, sometimes 9, sharply pointed, toothed, and lustrous leaflets sessile in pairs, the odd one being at the end of the rather stout, hairy, flattened, and grooved petiole. The staminate catkins hang in 3's from rather short, hairy stalks, and the pistillate flowers stand in 2- to 5-flowered spikes. The ellipsoid to obovate, reddish-brown nut-husk, $1\frac{1}{2}$ to 2 inches long and about $\frac{1}{8}$ of an inch thick, holds the more or less globose and more or less 4-ridged, light reddish-brown, thick- and hard-shelled nut. The dark-brown seed is small and sweet. The very stout, hairy twigs, gray in the second season, bear large, 3-lobed leaf-scars, above which stand the dark-brown lateral buds. The reddish-brown or yellowish trunk, which attains a diameter of 2 or 3 feet, is clothed with rather thin, gray bark with shallow, irregular fissures. The tree is usually 50 to 80 feet high, but may attain 100 feet.

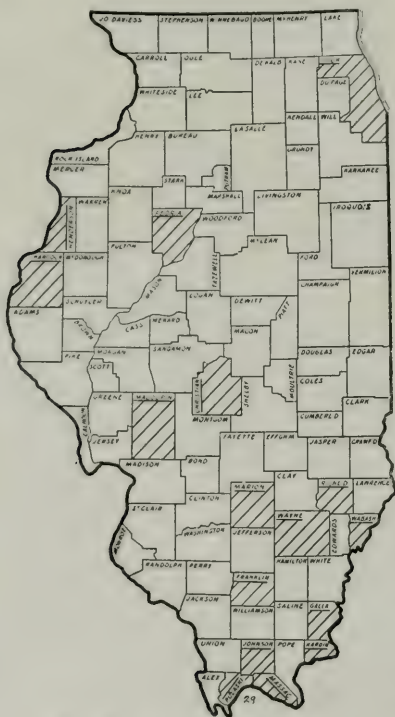


FIG. 29. Distribution of the Mockernut.

Distribution: The Hickory ranges from Massachusetts to Iowa, Florida, and Texas, finding suitable situations on dry slopes and ridges more often than on bottomlands. In Illinois, it occurs throughout the State, but is most abundant toward the south. It rarely occurs in pure stands, and it is found usually in the oak-hickory forests.

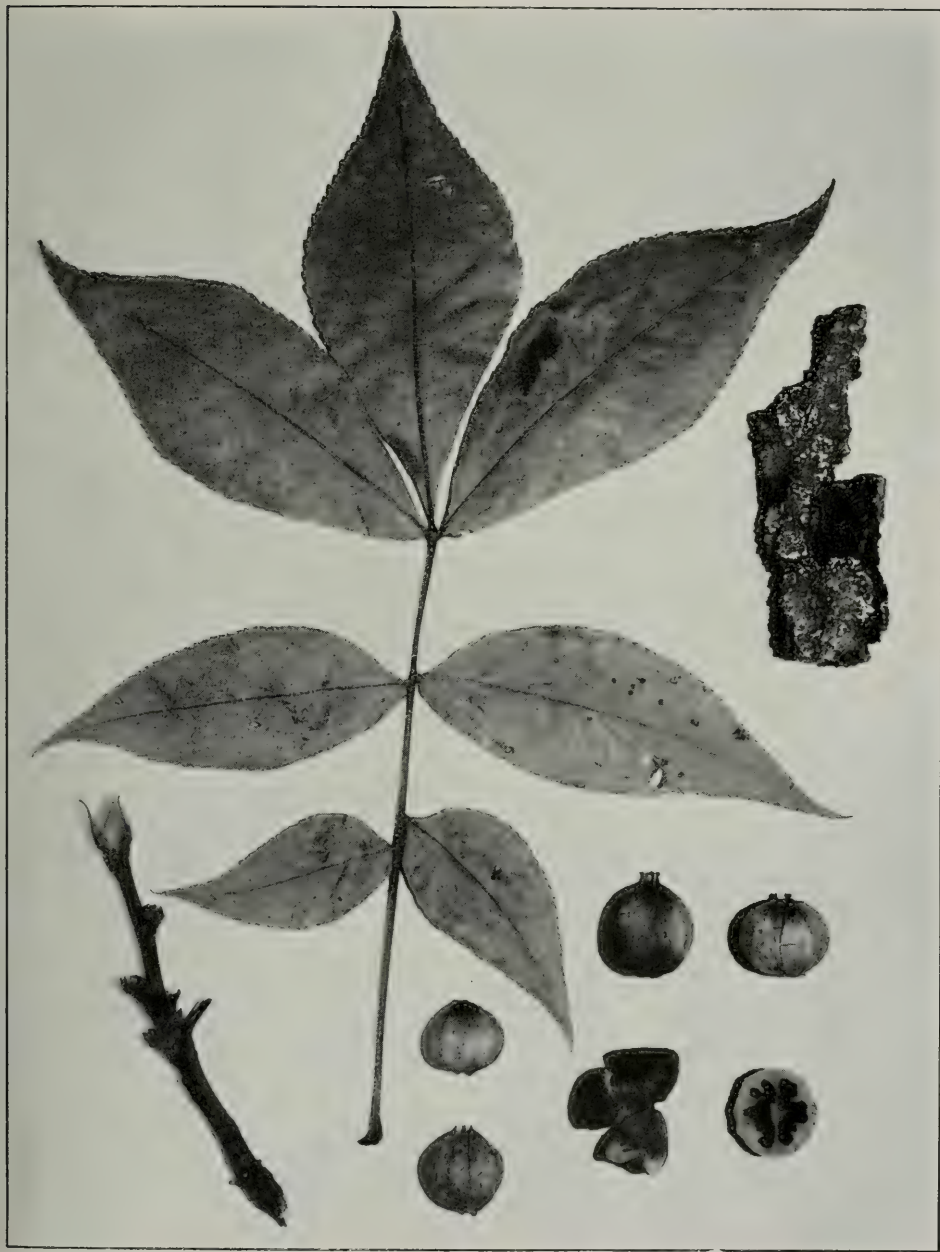


PLATE 21

CARYA ALBA K. Koch

HICKORY

Uses: The hard, close-grained wood of the White Hickory, a rich dark-brown at the heart and nearly white in the thick sapwood, is strong, heavy, and elastic. The toughness of White Hickory is almost proverbial. This tree furnishes the best grade of commercial hickory stock, which is put to the same uses as other hickory woods. It ranks especially high as fuel.

CARYA GLABRA SWEET

Pignut

The Pignut, or Pignut Hickory, is a moderate to large tree, with a narrow crown of short, spreading branches, the lowest of which have a tendency to droop. The alternate, compound leaves, usually from 8 to 12 inches long, have 5, or less often 7, sharp-pointed and sharp-toothed,



FIG. 30. Distribution of the Pignut Hickory.

dark-green, smooth leaflets 3 to 8 inches long by 1 to $2\frac{1}{2}$ inches wide, which are arranged in sessile pairs along the slender, slightly grooved petiole. The terminal leaflet sometimes has a short stalk. The slender staminate catkins, 3 to 8 inches long, hang in groups of 3 from long, drooping stalks, and the pistillate flowers are in few-flowered spikes. The globose to pear-shaped, reddish-brown nut-husk, about 1 inch long and not usually over $\frac{1}{8}$ inch thick, contains a brownish-white nut with a hard and thick shell. The seed is small and sweet. The slender, reddish branchlets are marked by pale lenticels and large, triangular leaf scars, above which stand pointed, light-brown buds $\frac{1}{3}$ to $\frac{1}{2}$ inch long. The lustrous, reddish-brown terminal bud, usually a little larger than the lateral buds, is covered by rather closely fitted scales. The trunk attains a diameter of 2 or $2\frac{1}{2}$ feet and is covered by gray, fissured bark. The height of the tree is from 60 to 90 feet, or rarely 120 feet.

Distribution: The Pignut Hickory, a tree of hillsides and dry ridges, ranges from Vermont to Delaware and westward into southern Illinois,



PLATE 22

CARYA GLABRA SWEET

PIGNUT

where it is one of the trees of the oak-hickory forest on the uplands. The tree seems to be more abundant in southern than in central Illinois.

Uses: The hard, close-grained wood of the Pignut Hickory, strong, tough, and elastic, furnishes a valuable grade of hickory timber, which is used, like other hickory woods, for tool handles, farming implements, and the like.

CARYA OVALIS SARGENT

Oval Pignut

This Pignut is a tree of considerable height, with small, spreading branches which form a narrow head. The alternate, compound leaves, usually 6 to 10 inches long, have 7, less often 5, long-pointed, finely toothed leaflets arranged on the sides of the slender, smooth petioles in

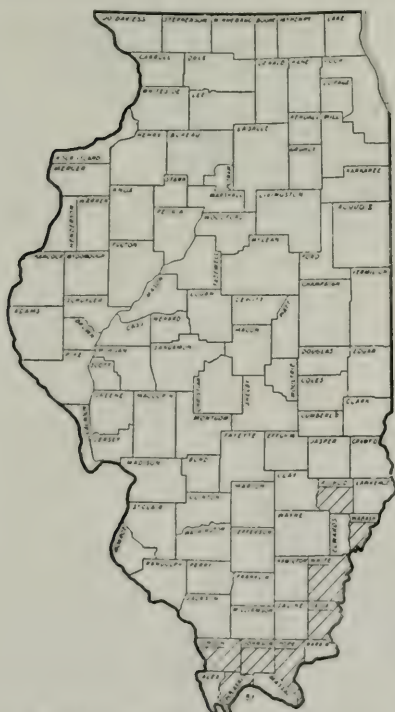


FIG. 31. Distribution of the Oval Pignut.

sessile pairs. The odd leaflet, which stands at the end of the petiole, is 6 or 7 inches long by $1\frac{1}{2}$ to 2 inches wide, with a $\frac{1}{4}$ - to $\frac{1}{2}$ -inch stalk. The staminate catkins, 6 or 7 inches long, hang in 3's from drooping, hairy stalks, and the pistillate spikes are 1- or 2-flowered. The ellipsoid nut-husk, 1 to $1\frac{1}{4}$ inches long, is finely hairy and very thin, and it incloses a pale, thin-shelled nut with a 4-angled top. The seed is small and sweet. The slender, lustrous branchlets are red-brown and marked with pale lenticels. The red-brown, lustrous, hairless terminal bud is often $\frac{1}{2}$ inch long—twice the size of the lateral buds. The trunk, only occasionally 3 feet in diameter, is covered by gray, slightly ridged bark, which separates freely into small plate-like scales. The tree is sometimes 100 feet high.

Distribution: This Pignut, a tree of hillsides and rich woods, ranges from New York to Iowa and southward to Georgia and Alabama. In Illinois, it is confined to the southern third of the State. There are three varieties of the species, each of which occurs in the State; but the distribution of all is shown without distinction on the map.



PLATE 23

CARYA OVALIS SARGENT

OVAL PIGNUT



PLATE 24

CARYA BUCKLEYI DURAND

BUCKLEY'S HICKORY

Uses: The wood of this Pignut has the usual characteristics of hickory and is serviceable for tool handles and agricultural implements. The tree is not common in Illinois and has little if any commercial significance.

CARYA BUCKLEYI DURAND

Buckley's Hickory

Buckley's Hickory is a small tree, with spreading and contorted branches which form a narrow crown. The leaves, which are 8 to 12 inches long, have 7 or, less often, 5 sharply pointed, blunt-toothed leaflets sessile on the rusty-haired, slender petioles. The staminate catkins are 2 to 3 inches long, and the pistillate spikes have 1 or 2 flowers. The nearly globose, finely hairy nut-husk, $1\frac{1}{4}$ to $1\frac{3}{4}$ inches long, is thin and contains a dark-reddish, 4-angled nut with a thin shell marked by conspicuous, pale veins. The slender, red-brown branchlets are capped by long-pointed terminal buds $\frac{2}{5}$ to $\frac{1}{2}$ inch long and 2 or 3 times as large as the flattened lateral buds. The trunk, usually 1 to 2 feet in diameter, bears thick, deeply furrowed, nearly black bark. The usual height of the tree is from 30 to 45 feet.

Distribution: Buckley's Hickory, a tree of the sandy uplands to the southwest, is known in Illinois by two of its varieties, *arkansana* Sargent having been collected by E. J. Palmer in Randolph and Gallatin counties, and *villosa* Sargent having been found by Ridgway in Richland County and by Palmer in Gallatin County.

CARPINUS LINNAEUS

Hornbeam

Family BETULACEAE

Small, deciduous trees, with alternate, broad-bladed, simple leaves. Flowers in catkins; the staminate catkins arising from buds near the end of the year-old growth; the pistillate catkins terminal on the new growth. Fruit a longitudinally ribbed nut, which separates in the autumn from a leaf-like, 3-lobed envelope. The fluted trunks have smooth, close, gray bark and hard, close-grained wood. The zig-zag twigs are slender, with small, roundish, pale pith, and bear buds covered by about twelve 4-ranked scales. There is no terminal bud.

About 15 species of *Carpinus* are recognized, all of them in the Northern Hemisphere. The range of the genus includes southeastern North America, much of Europe, and southeastern Asia. There is, however, only one species native to North America.

CARPINUS CAROLINIANA. WALTER

Hornbeam

Blue Beech

The Hornbeam is a bushy tree, with slender, slightly zig-zag, spreading branches that droop near the ends. The alternate, long-pointed, double-toothed leaves, 2 to 4 inches long by 1 to 1¾ inches wide, the blades of which often are falcate, are dull blue-green above and light-yellow beneath. The staminate cat-



FIG. 32. Distribution of the Hornbeam.

yellow beneath. The staminate catkins, about $1\frac{1}{2}$ inches long, have ovate, pointed scales which are green below the middle and red above; and the nearly erect pistillate catkins, $\frac{1}{2}$ to $\frac{3}{4}$ inch long, have hairy, green scales. The broadly oval, pointed nuts, about $\frac{1}{3}$ inch long, are crowded on slender twigs 5 to 6 inches long and hidden within their envelopes, which are 1 to $1\frac{1}{2}$ inches long by nearly 1 inch wide. The pointed buds, about $\frac{1}{8}$ inch long, are covered by chestnut-brown scales. The trunk, occasionally 2 feet in diameter, is fluted and covered by thin, gray bark sometimes marked by brownish, horizontal bands. The tree is seldom 40 feet high.

Distribution: The Hornbeam inhabits rich, moist, wooded soils from Nova Scotia and Florida westward to Minnesota and Texas. In Illinois, it grows throughout the length and breadth of the State in moist woods.

Uses: The hard, close-grained wood of the Blue Beech, light brown in the heart and white in the thick sapwood, is strong and very heavy. Although it may be used for levers, tool handles, mallets, and other small manufactured articles, it has little commercial value.

OSTRYA SCOPOLI

Hop Hornbeam

Family BETULACEAE

Small to medium-sized, deciduous trees, with alternate, broad-bladed, simple leaves. The flowers in catkins; staminate catkins long and clustered, from lateral buds near the end of the 1-year-old growth; pistillate



PLATE 25

CARPINUS CAROLINIANA WALTER

HORNBEAM

catkins terminal on the new growth. Fruit an obscurely ribbed nut inclosed by the much-enlarged, papery scales of the catkins. The slender, zig-zag twigs are round and have small, round, pale pith. There is no terminal bud, but the lateral buds are inclosed in about 6 spirally arranged scales. The trunk is covered with scaly bark.

This genus, which has four known species, is widely distributed in eastern North America and southern Europe and is found also in Japan. Two species occur in the United States, one of them limited to the high altitudes of the southern Rocky Mountains.

OSTRYA VIRGINIANA K. KOCH

Hop Hornbeam

Ironwood

The Hop Hornbeam is a small tree, with an open, round-topped crown of slender branches. The alternate, finely double-toothed, sharp-pointed leaves, 3 to 5 inches long by $1\frac{1}{2}$ to 2 inches broad, are thin but leathery, dull yellow-green and smooth above and pale-green beneath, with pale

hair in the angles of the veins. They have slender, round petioles about $\frac{1}{4}$ of an inch long and rounded or somewhat heart-shaped bases. The reddish-brown, hanging, clustered staminate catkins are cylindrical and about 2 inches long, and the pale-green pistillate catkins are $\frac{1}{2}$ to $\frac{3}{4}$ inch long. The fruit is a long-stalked, pendulous, cone-like structure, suggestive of the hop, with stinging hairs at the base of the papery scales, which incloses the pointed, flattened, chestnut-brown nutlets. The slender, zig-zag twigs, smooth and lustrous at first, become dull and dark reddish-brown. The trunk, which commonly attains a diameter of 8 to 15 inches, is covered by a thin grayish bark of narrow, oblong scales which are loose at the ends. The tree reaches a height of 25 to 40 feet.



FIG. 23. Distribution of the Hop Hornbeam.

Distribution: The Hop Hornbeam is a common tree on dry, gravelly, and stony soils from Nova Scotia



PLATE 26

OSTRYA VIRGINIANA K. Koch

HOP HORNBEAM

to South Dakota and southward to the Gulf of Mexico. It is found throughout Illinois except in the southern tip of the State. It is tolerant of shade and grows commonly among the oaks and other high trees on the high banks of streams.

Uses: The very hard, close-grained wood of the Hop Hornbeam, light-brown to nearly white in the heart and pale-white in the thick sapwood, is strong and tough but not very durable in the soil. Though used for fence posts, it is more serviceable for fuel and furnishes material for tool handles, mallets, and levers.

BETULA LINNAEUS

The Birches

Family BETULACEAE

Small to large, deciduous trees and shrubs, with alternate, broad-bladed, simple, petioled leaves and staminate and pistillate flowers in separate catkins; the staminate catkins long and pendulous; the pistillate catkins short and erect. Fruit an erect, cone-like structure, sessile or short-stalked on the ends of short branchlets, with oval nutlets nearly surrounded by lateral wings. The trunk covered with smooth, sometimes papery, resinous bark marked by long, longitudinal lenticels.

There are about 30 species of *Betula*, and the genus ranges throughout much of the Northern Hemisphere, some species forming great forests in the far north. Of the 12 species in North America, 9 are trees; and 2 of these are found in Illinois.

KEY TO THE ILLINOIS BIRCHES

- Bark of the trunk white.....*B. papyrifera* p. 101
 Bark of the trunk dark red-brown.....*B. nigra* p. 98

BETULA NIGRA LINNAEUS

Red Birch

River Birch

The Red, or River, Birch is a moderately large tree, divided at a height of 15 or 20 feet into 2 or 3 up-tilted limbs which divide in turn into slender branches that form a narrow, picturesque crown. The pointed, ovate, irregularly toothed leaves, $1\frac{1}{2}$ to 3 inches long by 1 to 2 inches wide, which are smooth above but hairy beneath, stand on slender, hairy, somewhat-flattened petioles about $\frac{1}{2}$ inch long. The staminate



PLATE 27

BETULA NIGRA LINNAEUS

RED BIRCH

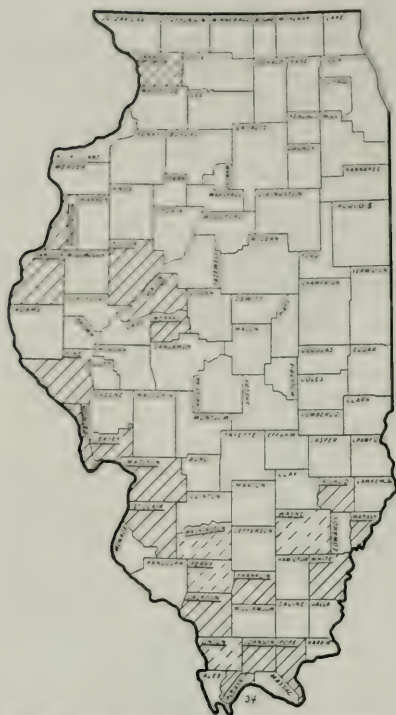


FIG. 34. Distribution of the River Birch.

catkins become 2 to 3 inches long; and the pistillate catkins, at first bright-green and about $\frac{1}{3}$ inch long, ripen in May and June into woody, cylindric, hairy cones 1 to $1\frac{1}{2}$ inches long, which stand erect on stout woolly stalks $\frac{1}{2}$ inch long. The little brown nuts, about $\frac{1}{8}$ inch long, are hairy toward their tips and are surrounded by 2 thin and hairy marginal wings. The smooth and lustrous, slender twigs, eventually dark reddish-brown, are covered with bark which peels off in thin, papery scales. The pointed, oval, hairy buds, which are appressed to the twigs, are covered by from 3 to 7 scales. The bark on young trees peels off in reddish-brown strips, but on mature trunks, which have attained a diameter of 2 or $2\frac{1}{2}$ feet, it often is dark brown and fissured and separates in plates. The tree is ordinarily 40 to 50 feet high, but sometimes it grows to 80 feet.

Distribution: The Red Birch, a tree of stream banks, ponds, and swamps, ranges from New Hampshire to Florida and westward into Minnesota and Texas. In Illinois, it grows throughout our southern and western regions; but though Deam has found it most abundantly in Indiana along the Kankakee River, it is not known along the lower reaches of this river in Illinois. In Hancock County, it is reported by Miss Kibbe as abundant along streams and in moist lowlands; and, in the south, it occurs on the Kaskaskia bottoms with Black and White oaks, hickories, maples, and others. In Wayne County, it grows with the Red and Black gums and the Pin and Swamp White oaks, while in Perry County it is associated also with the Black Cottonwood and a number of other oaks.

Uses: The fairly hard, close-grained wood of the Red Birch, light-brown in the heart and pale in the wide sapwood, is light but strong. It is used very largely in the manufacture of cheap furniture and other wooden articles, in turnery, and, especially in Illinois, as fuel and for the production of charcoal.

BETULA PAPYRIFERA MARSHALL

Canoe Birch

Paper Birch

The Canoe, or Paper, Birch, recognizable especially by its creamy-white, papery bark, is a moderate-sized tree, with short, slender, spreading branches which form a narrow, pyramidal or round-topped crown. The pointed, irregularly double-toothed leaves, 2 to 3 inches long by $1\frac{1}{2}$ to 2 inches wide, are thick and firm, dark-green above, and pale-yellowish beneath and stand on stout, yellow petioles $\frac{1}{2}$ to $\frac{3}{4}$ inch long. The cylindrical, brownish-yellow staminate catkins occur 2 or 3 together, and the pale-green pistillate catkins, 1 to $1\frac{1}{4}$ inches long, are solitary and terminal on short, lateral branches. The fruit is a pale-brown, cylindrical "cone" about $1\frac{1}{2}$ inches long, with elliptical, brown, wing-margined nuts about $1/16$ inch long at the base of each of its scales. The stout, smooth twigs become light orange and bear smooth, pointed buds, which are covered by 3 to 5 brown scales with downy margins. The trunk attains a diameter of 2 feet, and the tree grows to a height of 60 or 70 feet.

Distribution: The Paper Birch ranges from Labrador and the southern shores of Hudson Bay southward to Long Island in the east and Wyoming in the west. In Illinois, it is a rare tree and has but a limited range. According to Pepon¹ it is abundant at Rogers Park and north of Riverside. Good specimens have been seen, which were taken in Lake, Cook, and Carroll counties, and it is reported in Pepon's² list of the trees of Jo Daviess County.

Uses: The hard, close-grained wood of the Paper Birch is strong and light, reddish-brown at the heart and pinkish in the thick sapwood. It is used for fuel, as it burns well when green. The degree of hardness

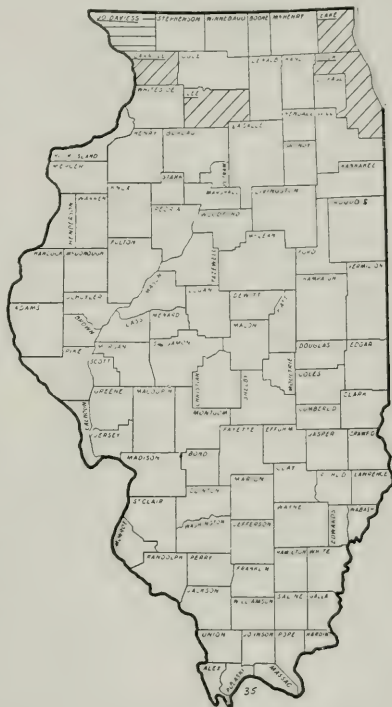


FIG. 35. Distribution of the Canoe Birch.

¹ Flora of the Chicago Region, p. 277.

² Trans. Ill. St. Acad. Sci. Vol. 3, p. 155. 1910.

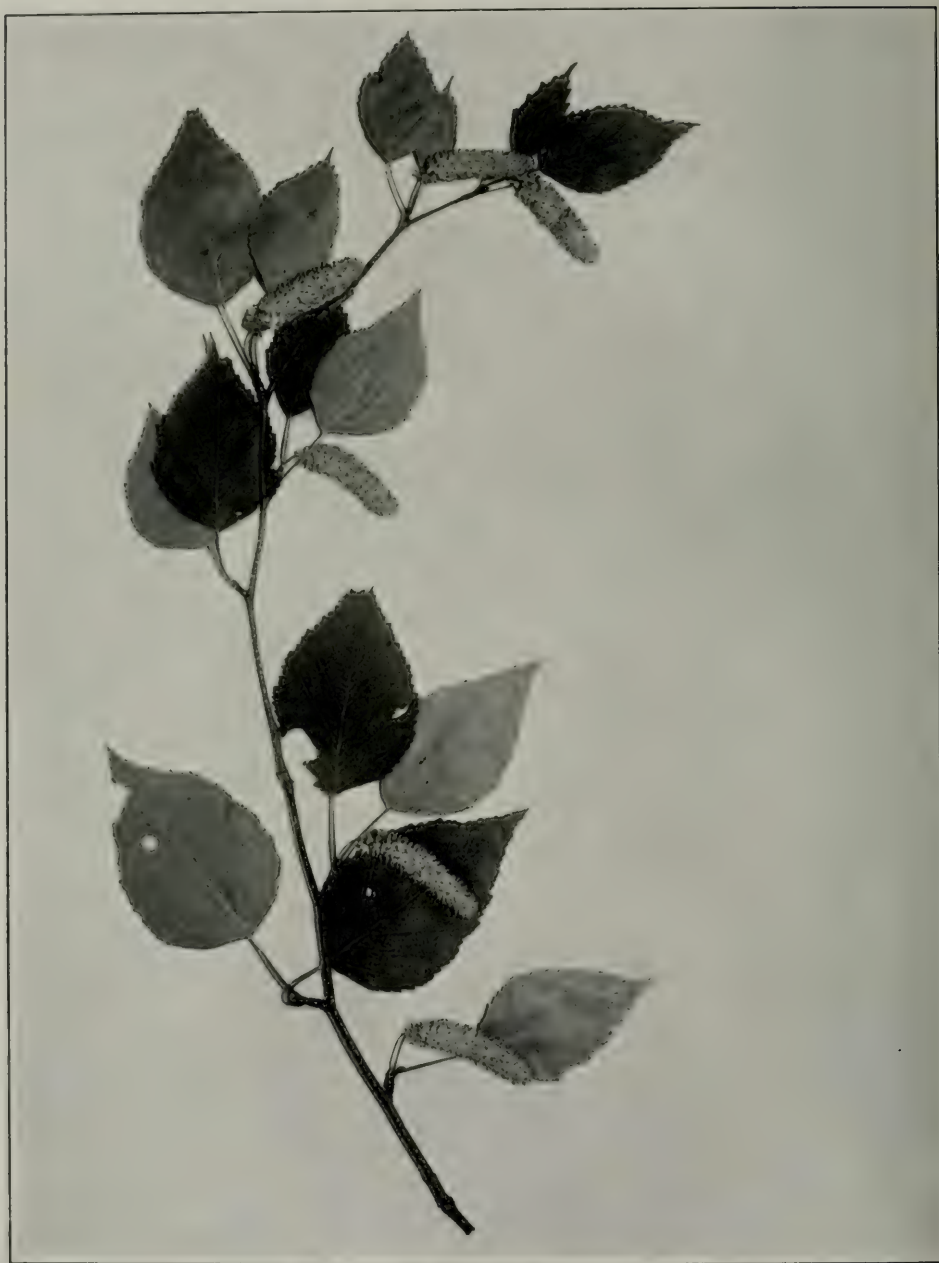


PLATE 28

BETULA PAPYRIFERA MARSHALL

CANOE BIRCH

of the wood is such as to make it very suitable for lathe work, and many small articles are made from it, such as shoe-shanks and shoe pegs, dowels, toothpicks, and many novelties. It is sawed into bars also, and these, after being seasoned, are shipped to Scotland, where they are made into spools.

OTHER BIRCHES IN ILLINOIS

Betula lutea Michaux, the Yellow Birch, has been collected by H. de Forest in Lee County. Two specimens were taken in September, 1922, from small trees at Whirlpool Rock and Marshmallow Rock, opposite Grand Detour, on the Rock River. This species is said by Waterman¹ to occur also in the bogs of Lake County, where he found trees with trunks 10 inches in diameter.

Betula lenta Linnaeus, the Cherry Birch, is represented in the herbarium of the University of Illinois; but it is to be noted that this specimen, collected by T. J. Burrill at Princeton, was taken from a cultivated tree in Bryant's Nursery.

FAGUS LINNAEUS

Beech

Family FAGACEAE

Large, deciduous trees, with alternate, broad-bladed, short-stalked, simple leaves and slender, round, zig-zag twigs containing small, round pith. Staminate and pistillate flowers separate but on the same tree; the staminate in long-stalked, globular heads near the base of the new growth, and the pistillate in 2- to 4-flowered, stalked clusters toward the end of the new growth. The fruit is a woody, prickly, 4-parted burr containing 3 three-angled nuts.

The 8 species of *Fagus* are all in the temperate regions of North America, Europe, and Asia, although a dozen beech-like trees and shrubs classed in the genus *Nothofagus* are known in southern Australia, New Zealand, and in Chile and Terra del Fuego. There is but one North American Beech.

¹ Trans. Ill. Acad. Sci. Vol. 16, p. 217. 1923.

FAGUS GRANDIFOLIA EHRLHART**Beech**

The Beech is a moderate to large tree, with a compact, narrow crown borne high on the long, straight trunk. The alternate, sharply pointed, sharply and coarsely toothed leaves, $2\frac{1}{2}$ to 5 inches long by 1 to 3 inches wide, are thin but leathery, dull-green above and pale-green and shiny beneath, where the rib-like veins have tufts of hairs in their axils. The short, round, stocky petioles are about $\frac{1}{4}$ inch long. The globular heads of staminate flowers, an inch in diameter, hang on slender stalks 2 inches long, and the pistillate flowers usually stand in pairs, each on a short, woolly stalk. The fruit is a short-stalked, prickly burr $\frac{3}{4}$ inch long, which splits into 4 parts, setting free the 2 shiny, brown, 3-sided nuts. The slender, zig-zag, bright-brown twigs bear narrow, conical, sharply pointed, divergent buds $\frac{3}{4}$ to 1 inch long, which are covered by 10 or more hairy-margined scales. The columnar trunk, which becomes 2 to 4 feet in diameter, is covered by dull-gray bark that is thin and smooth and often mottled with dark spots. The ordinary height of the tree is between 60 and 80 feet.

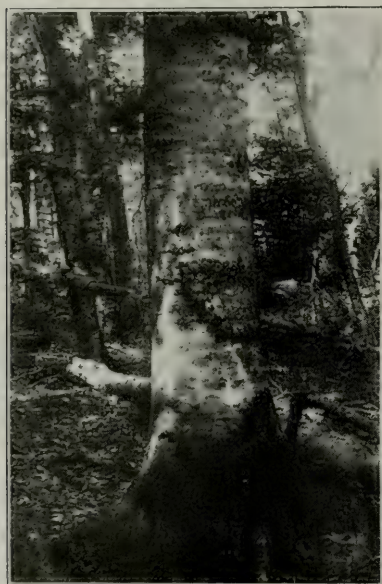


FIG. 36. A typical American Beech. Photo from the Field Museum of Natural History.

Distribution: The Beech ranges from Nova Scotia southwestward into Minnesota and southward into Florida and Texas. In Illinois, it is now a tree of limited distribution, rare in the north and by no means abundant in the south. Formerly, it may have been more abundant, for early writers say that cattle thrived amazingly on beech mast, their flesh acquiring a superior flavor; and A. H. Worthen, in his *Geology of Illinois*, published in 1866, says that "the steep, rugged hills in the southwest corner of Pulaski County were covered with beech timber," the beech extending "on the slopes of the bluff hills a short distance east of the Illinois Central railroad and also southward into the bottom."

In northern Illinois, the Beech is found only in Lake County, where there are groups of trees in a ravine near Highland Park and in the Petti-



PLATE 29

FAGUS GRANDIFOLIA EHRLHART

BEECH

bone Creek ravine at Fort Sheridan. There was at one time a clump of Beech in a wood one mile north of Edgebrook; but Pepoon states that in 1926 the wood had been cut over and the trees lost.

In southern Illinois, the range of the Beech, which is much the same as the range of the Tulip Tree, extends from Vermilion County southward around the State and up the Mississippi into Randolph County. Throughout this territory, the tree appears to find small areas in the bottoms of small valleys and the sides of ravines, where cherty and gravelly soils occur, suitable for its growth; and in these situations it is associated commonly with the Tulip Tree, oaks, hickories, maples, gums, and the Elm. In Ubedam Hollow, in Union County, where Beeches grow with Tulip and Cucumber trees, one tree had a diameter of 28 inches and a clear, merchantable trunk 62 feet long.

Uses: The hard, close-grained wood of the Beech, light- to dark-red in the heart and nearly white in the thin sapwood, is tough and strong; but it is hard to season and is not durable in the ground. Since it takes a high polish, it is used considerably for furniture and tool handles. It is used also for veneers, distillation and fuel, ranking with birch and hard maple for the last purpose. It has a slight, silver grain on the radial surface, which gives it a pleasing effect when used



FIG. 37. Distribution of the Beech.

for flooring and stairways. Since the development of wood-preserving processes, beech is being used for railroad ties; and in 1925 about 120,000 board feet were cut, of which a large amount probably was used for ties.

CASTANEA ADANSON**The Chestnuts**

Family FAGACEAE

Deciduous trees or shrubs, with alternate, broad-bladed leaves on short petioles. Staminate and pistillate flowers separate, the former grouped, 3 to 7 together, at small intervals along the axis of a long catkin, which grows single or several together toward the base of a spike-like structure arising from the axil of the new leaf. Fruit a stalkless, globose burr densely covered with sharp spines, splitting into 2 or 4 parts to liberate 1 to 3 globular, chestnut-brown, hairy-tipped nuts. Twigs of moderate size, more or less fluted, with star-shaped pith and stalkless, oval buds covered by 2 or 3 exposed scales. The trunk has furrowed bark.

Castanea, with its 7 species, is wide-spread in the Northern Hemisphere, ranging through eastern North America, southern Europe, and Northern Africa to China, Korea, and Japan. This genus, like Carya, is ancient. Fossils found in many parts of Europe as well as in New Jersey, Colorado, Wyoming, and Oregon, in British Columbia, Alaska, and Greenland, indicate that there were not less than 11 species in the world previous to the Ice Age. Two of the modern species, one European and one American, are survivors of these ancient trees.

There are 3 native species of Castanea in the United States, one of which occurs in Illinois.

CASTANEA DENTATA BORKHAUSEN**Chestnut**

The Chestnut is a moderately large, very bulky tree, usually with a few stout, horizontal limbs which form a broad, round-topped crown. The large, sharply pointed, coarsely and very sharply toothed leaves, 6 to 8 inches long by 1 to 1½ inches wide, are thin and dull, dark-green above and pale-yellow beneath. The stout, hairy petioles are about ½ inch long. The flowers appear in late June or July, the staminate flowers in erect, stalked catkins 6 to 8 inches long, the pistillate flowers in clusters of 2 to 5 toward the base of slender, hairy catkins 2½ to 5 inches long. The stalkless, globular, brown burr, which is densely covered with long, branched, sharp spines, splits into 4 parts. Within it are from 1 to 3 lustrous brown nuts with sharp, hairy tips and with bases marked by large pale scars. The stout, lustrous, dark-brown twigs, which are more or less

fluted, have no terminal bud; but the half-round leaf-scars, flanked by long stipule scars, are surmounted by obliquely formed, pointed, divergent buds covered by 2 or 3 exposed scales. The trunk, often 3 to 4 feet in diameter, is covered by gray bark divided by shallow fissures into broad, flat ridges which often have a distinct spiral course around the trunk.

Distribution: The range of the Chestnut extends from Maine westward to Michigan and southward to Delaware and Tennessee. In Illinois, it is found native only near Olmstead, in Pulaski County, where there is a grove of trees, some 80 acres in extent, on rolling clay ridges. These trees were mentioned by Flagg and Burrill¹ and were described by the Rev. E. B. Olmstead in 1876 in the following words: "I suppose that these trees are indigenous. They grow on a ridge in section 23, town 15, range 1 east, about a quarter of a mile from the Ohio River and overlooking it. . . I took a position in their midst today, and counted, without moving, thirty-five beautiful and symmetrical trees, averaging in diameter about 22 inches, and in height 50 or 60 feet. When I came to this place in 1839 there were a great many more than at present. About 25 years ago I saw a tree cut down and worked up into rails. It was immensely tall and four or five cuts were taken off for rails ten feet long. I measured the stump of that tree today. . . and making allowance for sap and bark which are gone, found it six feet, two inches, three feet from the ground. Comparing this with a small one the concentric rings of which we counted, the noble tree was 250 years old when it was cut down. . . These trees did not originate with any civilized nation. No doubt, the Indians for many generations built their council fires under their branches, but they did not plant them."

Among a collection of woods prepared by Mr. B. T. Gault, of Glen Ellyn, in 1900, and presented to the University of Illinois, there is a specimen taken from a limb of one of these trees; and the photograph which accompanies it shows a tree $4\frac{1}{2}$ to 5 feet in diameter, indicating an age of between 200 and 250 years. After a visit to these chestnuts in 1916, Dr. William Trelease² reported that most of the large trees had been destroyed but that an abundant seeding had resulted in a considerable growth of young trees. He reports also that at present Box Elder, Red Maple, hickories, Hackberry, Persimmon, Beech, White Ash, and numerous other trees are associated with the Chestnut, and give the Illinois location much the same aspect as the usual habitat of the tree to the east and south.

Uses: The soft, coarse-grained wood of the Chestnut is light and weak, but durable in the soil. It is used largely for railroad ties, posts,

¹ Ninth Report Ill. Ind. University. 1878. Page 268.

² Trans. Ill. St. Acad. Sci. Vol. 10, p. 143. 1917.



PLATE 30 •

CASTANEA DENTATA BORKHAUSEN

CHESTNUT

poles, and for cheap furniture and interior finishing of houses. The tree is also the source of a tannin extract used in tanning hides. The commercial chestnuts of the eastern United States also come from this tree.

QUERCUS LINNAEUS

The Oaks

Family FAGACEAE

Small to large trees with alternate, variously lobed or entire, usually deciduous leaves, which are disposed in 5 vertical ranks along the branchlets. Staminate and pistillate flowers separate but on the same tree; the former in long, pendulous, clustered catkins, the latter solitary, in few-flowered spikes from the axils of the new leaves. Fruit a nut, called an acorn, which is more or less inclosed by a persistent cup. Twigs moderate to slender and fluted, with moderate, star-shaped pith. Buds with numerous, 5-ranked scales, sessile above moderate to small, half-round leaf-scars. Trunk of hard and close-grained, but sometimes porous and brittle, wood, covered by a scaly or furrowed bark.

The genus *Quercus*, of which more than 350 species exist, inhabits the temperate regions of the Northern Hemisphere and extends into the tropics in situations of a high altitude. Our modern oaks are the descendants of very ancient trees. Between 20 and 30 forms have been recorded, from fossils, as existing at about the time of the Ice Age, and of these only 3 or 4 are now extinct. There are, at present, 84 species in the United States; and of these, Illinois contains 19 tree forms, 8 being white oaks and 11 black oaks.

KEY TO THE ILLINOIS OAKS

- Leaves with bristle tips; bark dark, furrowed; acorn-shells silky-hairy inside; acorns mature at the end of 2 seasons (Black Oaks).
 - Leaves entire, bristle-pointed (Willow Oaks).
 - Leaves and buds without hairs; acorns stalked.....**Q. Phellos** p. 131
 - Leaves hairy beneath; buds more or less hairy; acorns practically sessile.....**Q. imbricaria** p. 134
 - Leaves more or less distinctly lobed, the lobes also bristle-tipped.
 - Leaves shallowly lobed, blade much expanded toward the tip
Q. marylandica p. 128
 - Leaves deeply and pinnately lobed.
 - Leaves pale and velvety beneath.
 - Leaves deeply cut.....**Q. rubra** p. 124
 - Leaves shallowly cut.....**Q. rubra pagodaefolia** p. 126
 - Leaves green on both sides.
 - Leaves dull above, 7- to 11-lobed.....**Q. borealis** p. 112
 - Leaves shiny on both faces, generally 5- to 9-lobed.
 - Acorn cup shallow, saucer-shaped.
 - Leaves generally 7-lobed; acorn oval.....
Q. Shumardii p. 116
 - Leaves 5- to 7-lobed; acorn globose.....
Q. palustris p. 120
 - Acorn cup deep, cup-like.
 - Cup-scales tightly appressed....**Q. ellipsoidalis** p. 117
 - Scales forming a loose fringe at the cup's edge
Q. velutina p. 122
 - Leaves never with bristle tips; bark gray and more or less scaly; acorn shells not hairy inside; acorns maturing at the end of 1 season (White Oaks).
 - Leaf-margins sinuate, coarsely toothed only (Chestnut Oaks).
 - Acorns sessile or very nearly so.....**Q. Muehlenbergii** p. 153
 - Acorns long-stalked.
 - Acorn stalks much longer than the petioles.....**Q. bicolor** p. 146
 - Acorn stalks not longer than the petioles.
 - Cup scales separate and distinguishable; end buds distinctly red-tinted.....**Q. Prinus** p. 149
 - Cup scales appearing grown together, distinguishable only at the tips; end buds light-brown to tan
Q. montana p. 152
 - Leaves more or less deeply lobed.
 - Leaves not hairy beneath, usually 7- or 9-lobed.....**Q. alba** p. 144
 - Leaves hairy beneath.
 - Scales forming a conspicuous fringe around the rim of the cup.....**Q. macrocarpa** p. 135
 - Cup scales not forming a conspicuous fringe.
 - Cups nearly inclosing the acorn.....**Q. lyrata** p. 138
 - Cups covering only $\frac{1}{3}$ to $\frac{1}{2}$ of the acorn.....**Q. stellata** p. 140

QUERCUS BOREALIS MICHAUXVariety **MAXIMA** Ashe**Red Oak**

The Red Oak is a tree of large size, with a narrow head of stout branches. The smooth leaves, dull-green above and yellow-green below, which are from 5 to 9 inches long by 4 to 6 inches wide, are divided almost half way to the midrib into 7, 9, or usually 11 lobes each of which

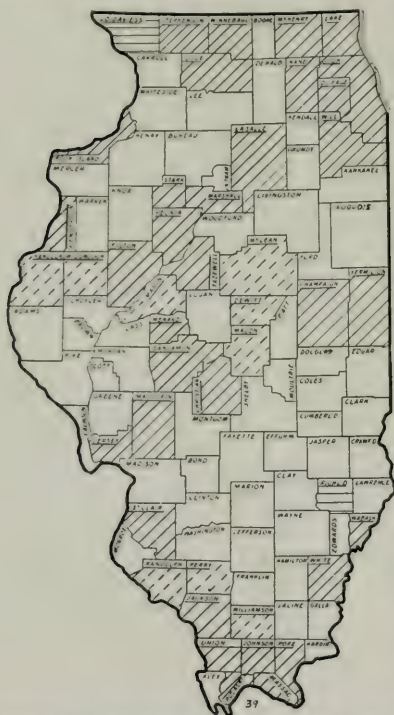


FIG. 38. Distribution of the Red Oak.
(*Quercus borealis* var. *maxima*)

usually has 3 smaller, bristle-tipped lobes at its point. The staminate catkins are 4 or 5 inches long, and the pistillate flowers stand on short, hairless stalks in the axils of the new leaves. The pale-brown, lustrous acorns, 1 to 1¼ inches long by ½ to ⅔ inch wide, stand alone or in pairs and are sessile or very short-stalked. Their shallow cups are covered with red-brown, hairy scales, which have thin, dark-colored margins and tips. On the dark-red to brown branchlets, the oval, pointed buds, about ¼ inch long, are covered by thin, pointed, chestnut-brown scales. The trunk, covered by dark-brown bark which is fissured into low, continuous, flat-topped ridges, becomes 3 to 4 feet in diameter, and the tree attains a height of 70 to 80 feet.

Distribution: The Red Oak is known in Illinois only by this variety, which differs from the typical tree in its greater size and the larger acorns borne in shallow cups. One of the most generally distributed trees of the Northern States, east of the Great Plains, it occurs throughout Illinois, choosing porous, sandy or gravelly clay soils in preference to swamps or dry slopes and ridges. A. G. Vestal¹, in a careful study of the forests on sandy ridges, became convinced that a process of succession has taken place, ranging from Black Jack Oak, when the soil was young and poor, to a Red Oak and Hard

¹ Ill. St. Lab. Nat. Hist. Bul. Vol. 10, Art. 1. 1913.



PLATE 31

QUERCUS BOREALIS MAXIMA ASHE

RED OAK

Maple stand, as the soil was improved; and the latter he believes to be the climax, or highest type of forest possible, in such situations. In 13 counties, strip lines run by our survey party showed the Red Oak to be associated most commonly with the White and Black oaks and with hickory, as well as with other trees such as Elm, Ash, Burr Oak, Beech, and

Mulberry. The largest Red Oak encountered had attained a height of 107 feet, with a trunk diameter of 38 inches.

Uses: The hard, close-grained wood of the Red Oak, light red-brown in the heart, is heavy and strong, but it is not durable in the soil. Red Oak fence posts last, on an average, only about 5 years in Illinois. But the lumber, next to white oak, is the most common oak on the market. It is used extensively in manufacturing furniture and for interior finishing in buildings, for the "silver grain" so conspicuous in quarter-sawed material lends the wood a distinctive and pleasing pattern. The strength of Red Oak timbers makes them valuable for construction and for mine timbers and, when treated, for railroad ties and fence posts.



FIG. 39. Red Oak growing with maples and ashes in Brownfield Woods, Champaign County.



PLATE 32

QUERCUS SHUMARDII BUCKLEY

RED OAK

QUERCUS SHUMARDII BUCKLEY

Red Oak

This Red Oak is a tall tree, with a broad, open head of stout, spreading branches. The dark-green and lustrous leaves, 6 to 8 inches long by 4 to 5 wide, which are paler beneath and have tufts of pale hairs in the axils of their veins, are deeply divided into 7, less often 5, lobes. The



FIG. 40. Distribution of the Red Oak (*Quercus shumardii*) and its variety, Schneck's Oak.

Schneck's Oak, along the borders of streams and swamps. It is associated in these situations with Black, White, Pin, Cow and Swamp Spanish oaks, as well as Elm, Sycamore, Black Gum, ashes, and hickories.

Schneck's Oak, named in honor of Dr. Jacob Schneck of Mt. Carmel, is distinguished by the fact that the acorn cups are deep and cup-shaped. It has the same general range in Illinois as the species; but in point of fact it has not been found in Perry, Franklin, Johnson, Richland, and St. Clair counties, while it is recorded from Pope and Jackson counties.

Uses: The hard, close-grained wood of this oak, light reddish-brown in the heart, is heavy and strong. It is used for furniture, the in-

slender, hairless petioles are 2 to 2½ inches long. The slender staminate catkins are 6 or 7 inches long, and the pistillate flowers stand singly on hairy stalks. The long-oval acorn, ¾ to 1¼ inches long by ½ to 1 inch wide, is held in a thick, saucer-like cup covered by closely appressed, thin, and usually hairy scales. The grayish-brown, smooth branchlets bear pointed buds about ¼ inch long, which are covered by gray, smooth scales. The trunk, which is inclosed by thick, ridged bark, sometimes grows to a diameter of 5 feet; and the tree may become 120 feet high.

Distribution: Inhabiting the moist soils of stream banks and swamps, this Red Oak ranges from Texas to Florida and northward into Iowa and southwestern Michigan. In Illinois, it is to be found only in the southern counties, where it occurs with its variety, *Schneckii* Sargent, known as

terior finish of houses, and heavy construction. In southern Illinois, it furnishes mining materials such as props. One average 80-year-old tree growing on the Big Muddy bottoms near Benton, Franklin County, produced 2 railroad ties, worth \$1.60, 15 mine props, valued at \$2.25, and 2 motor ties worth \$0.50, the entire tree having a total value of \$4.35.

QUERCUS ELLIPSOIDALIS E. J. HILL

Black Oak

Jack Oak

The Black Oak, called also Hill's Oak and Jack Oak, is a tree of only moderate size, with a narrow, oblong crown of ascending, forked branches. The 5- to 7-lobed, deeply divided leaves, 3 to 5 inches long by $2\frac{1}{2}$ to 4 inches wide, are bright-green above and paler and almost entirely hairless below. The slender petioles are $1\frac{1}{2}$ to 2 inches long. The staminate catkins become $1\frac{1}{2}$ to 2 inches long, and the pistillate flowers stand alone or 2 or 3 together on stout, hairy stalks. The nearly globular, chestnut-brown acorns, supported on very short stalks, are half-buried in deep cups, which are thin, light red-brown, and closely covered by narrow, hairy scales. The twigs, covered at first by matted pale hairs, become dark-brown. The buds, $\frac{1}{8}$ inch long, are covered by lustrous, brown, hairy-margined scales. The trunk, which is covered by thin, brown bark divided by shallow fissures into thin plates, may become 3 feet in diameter; and the height of the tree is usually between 60 and 70 feet.

Distribution: Hill's Oak is a tree of very limited distribution in the North-central States. In Illinois, it grows commonly throughout the northern fourth of the State. According to Trelease¹, it does not go farther south than a line drawn from Rock Island to Kankakee, but through this territory it abounds on sandy and clayey uplands as well as in moister,



FIG. 41. Distribution of the Black Oak.

¹Trans. Ill. St. Acad. Sci. Vol. 12, pp. 108-118. 1919.



PLATE 33

QUERCUS ELLIPSOIDALIS E. J. HILL

BLACK OAK



PLATE 34

QUERCUS PALUSTRIS MUENCHHAUSEN

PIN OAK

sandy situations. On the pure sands of Lee County, where it is a pioneer tree, it grows large enough to be cut for railroad ties. It grows on the Lee County sands with hickory, Black and Scrub oaks, and sometimes with Burr Oak, while in La Salle County it is common in the dry oak forests, called locally "woodland pastures," in company with the Black, White, Chinquapin, and Shingle oaks.

Uses: The wood of the Jack Oak is similar to that of the Black Oak and can be used for such purposes as posts, railroad ties, rough construction, and fuel.

QUERCUS PALUSTRIS MUENCHHAUSEN

Pin Oak

Swamp Spanish Oak

The Pin Oak is a moderately large tree, with an open head of drooping, ridged branches, upon which are numerous small, drooping branchlets. The deeply 5- to 7-lobed leaves are 4 to 6 inches long by 2 to 4 inches wide; they are thin and firm, dark-green and very shiny above,



FIG. 42. Characteristic stand of Pin Oak on the bottomland of the Kaskaskia River.

paler and with tufts of pale hairs in the axils of the large veins below; and they stand on slender, yellow petioles $\frac{1}{2}$ to 2 inches long. The staminate catkins are 2 or 3 inches long, and the pistillate flowers are often in pairs on short, hairy stalks. The globose acorns, about $\frac{1}{2}$ inch in diameter, rest in thin, saucer-like, shallow cups, which are closely covered by thin scales. The buds on the slender, tough twigs are about $\frac{1}{8}$ inch long and are covered by light-brown, finely hairy scales. The trunk, commonly not over 2 to 3 feet in diameter, is generally smooth. The tree attains a height of 70 or 80 feet.

Distribution: The Pin Oak is found on the borders of swamps and on river bottoms from Connecticut west to Iowa and south to North Carolina in the East and Oklahoma in the West. It is found in characteristic situations throughout Illinois, but grows most commonly in the extreme south, although trees of a good size occur also on some of the older and

better established islands of the Mississippi and Illinois Rivers. In the Kaskaskia bottoms, there are trees 75 years old and 75 feet high which have a diameter of 20 to 24 inches; while the largest tree that has been measured was 112 feet high and 45 inches in diameter.

With the Pin Oak grow such trees as ash, maples, hickories, the Swamp White, Cow, and Burr oaks, Cottonwood, River Birch, Black Walnut, the Red and Black gums, and several others.

Uses: The hard, though coarse-grained, light-brown wood of the Pin Oak, often called "water oak" in the southern counties, is strong and heavy. It is suitable for all kinds of rough construction, such as barn sills, bridge planking, mine cars, and the like; but, because the tree prunes itself very poorly, pin oak lumber contains a considerable number of knots and is, on that account, not so good for interior finishing or for beams, when strength is required. Its outstanding use is for piles.

In the early days Pin Oak was used for shingles and clapboards. The logs were cut in short lengths of 3 or 4 feet and then quartered. Pieces with straight grain were selected, and from them the shingles and clapboards were split, or "rived," by means of a knife-like tool which was driven through the wood with a mallet. The shingles and clapboards so produced were durable, but in the sun and wind they had a tendency to curl, which gave the roofs made of them a shaggy appearance.

The Pin Oak is not an abundant tree in our upland forests, but on the bottomland it is more common, constituting 3.3 per cent of the stand in the Cypress and mixed hardwood type and 13.3 per cent of the stand in the mixed hardwoods of main streams. In the virgin bottomland forests, the Pin Oak on a sample acre amounted to 2,360 board feet, a quantity exceeded only by the Elm, Soft Maple, and the Red Gum. As the tree grows rapidly, its use should be encouraged both for forest planting and for decorative purposes.



FIG. 43. Distribution of the Pin Oak.

QUERCUS VELUTINA LAMARCK

Black Oak

Yellow-bark Oak

The Black Oak is a moderately high to very high tree, with an irregular, oblong crown of rather slender branches. The deeply 5- to 7-lobed, thick, and leathery leaves, which stand on petioles 3 to 6 inches long, are dark-green and lustrous above, paler and more or less hairy beneath, and

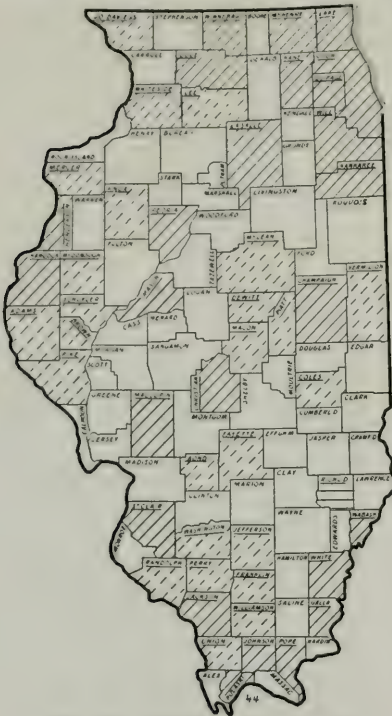


FIG. 44. Distribution of the Black Oak.

measure generally 5 to 6 inches long by 3 to 4 inches wide, though they may be either very much smaller or larger. The hairy staminate catkins are 4 to 6 inches long; and the pistillate flowers usually stand in groups of 2 or 3 on short, hairy pedicels. The oval, reddish-brown acorn, $\frac{1}{2}$ to $\frac{3}{4}$ inch long, is about half imbedded in a thin, rather deep cup, the scales of which form a fringe-like border at the rim. The stout, dull-brown twigs bear yellowish-gray, 5-angled, hairy buds $\frac{1}{4}$ to $\frac{1}{2}$ inch long. The mature bark on the trunks, which attain a diameter of less than 3 feet, is nearly black and divided by fissures into broad, rounded ridges; but the inner bark is orange. Though usually growing 65 to 75 feet high, the tree may attain a height of 125 feet.

Distribution: The Black Oak ranges, on dry and gravelly uplands and ridges, from southern Maine to Nebraska and southward to Florida and eastern Texas. It is not surprising, therefore, to find it generally distributed through the entire State of Illinois. It occurs most commonly with White Oak and hickories. In the dry oak forests of the uplands, 28 per cent of the trees are Black Oak. In La Salle County it constitutes about 20 per cent of the oak-hickory forest. In Mason, Lee, Kankakee, and other counties, according to Vestal¹, it grows with Jack Oak as one of the pioneer trees on sand ridges.

Uses: The hard, coarse-grained, reddish-brown wood of the Black Oak is strong and heavy, but is not durable in the soil. Black oak fence

¹ Ill. St. Lab. Nat. Hist. Bul. Vol. 10, Art. 1. 1913.



PLATE 35

QUERCUS VELUTINA LAMARCK

BLACK OAK

posts last about 5 years—one half as long as post oak and white oak posts—but with preservative treatments, which the structure of the wood renders effective, it can be used profitably for both posts and railroad ties. It serves also for all kinds of rough construction, such as bridges, railroad and mine cars, piling, and props.

In the virgin forests of the Wabash Valley bottomlands, the Black Oak yields over 2,000 board feet per acre. In White County, on the bottomlands, a Black Oak tree, the largest seen in the State, measured 125 feet high and 37 inches in diameter.

QUERCUS RUBRA LINNAEUS

Spanish Oak

Red Oak

The Spanish Oak is a large tree, with a broad, round-topped crown of stout, spreading limbs. The deeply 5-lobed leaves, which are dark and lustrous above but pale and velvety beneath, are 6 or 7 inches long and 4 or 5 inches wide. The side lobes of the leaves gradually narrow to

a point, usually without being toothed or lobed near the end. The woolly staminate catkins are 4 or 5 inches long; and the pistillate flowers stand singly on short, woolly pedicels. The bright, orange-brown acorns, about $\frac{1}{2}$ inch long, stand in cups of various shapes, sometimes flat and saucer-like, sometimes deep and cup-like. The slender, dark-red or brown twigs bear pointed, chestnut-brown buds about $\frac{1}{4}$ inch long; and the trunks, which become 2 or 3 feet in diameter, are covered by dark, thick bark, which is shallowly fissured into regular, flat-topped ridges. The usual height of the tree is between 70 and 80 feet.

Distribution: The Spanish Oak is a southern tree with a range that extends from southern Pennsylvania to Florida and westward to Missouri in the north and Texas in the south. In Illinois, it occurs as a native only in the southern third of the State, where it is found on dry hills.

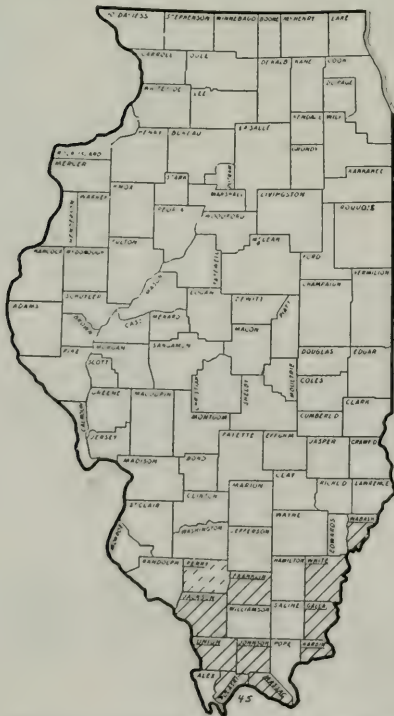


FIG. 45. Distribution of the Spanish Oak.



PLATE 36

QUERCUS RUBRA LINNAEUS

SPANISH OAK

Uses: The hard and coarse-grained but not very durable, light-red wood of the Spanish Oak is made into rough lumber; and, because it is less subject to defects than lumber from other red oaks, it finds considerable use in the manufacture of chairs, tables, and similar articles. The bark is rich in tannin.

QUERCUS RUBRA LINNAEUS

Variety **PAGODAEFOLIA** Ashe

Swamp Spanish Oak

Red Oak

The Swamp Spanish Oak, though held as a variety of the Spanish Oak, is sufficiently different from it to be considered as a separate tree. It is much larger than the Spanish Oak; and, though of the same habit of growth, its leaves are from 5- to 11-lobed and are much less deeply cut

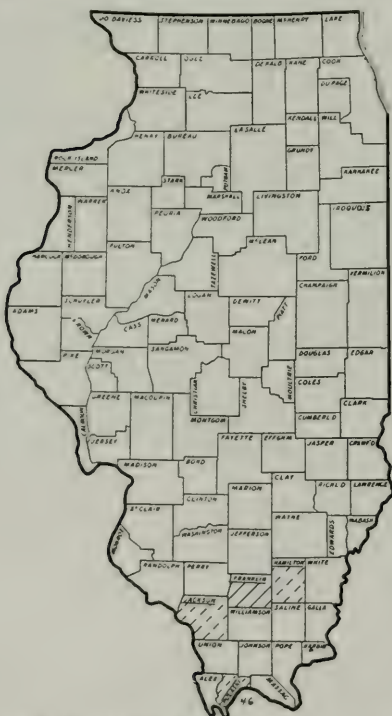


FIG. 46. Distribution of the Swamp Spanish Oak.

to 8 inches long by 5 to 6 inches wide and, before falling, they turn bright-yellow. The flowers and acorns are similar to those of the Spanish Oak; but the fine-hairy, reddish-brown branchlets bear prominently 4-angled buds $\frac{1}{4}$ inch long. The bark on the trunks, which sometimes grow to a diameter of 4 or 5 feet, is about an inch thick and breaks, on the surface, into plate-like scales. The height of the tree is often 100 feet or more.

Distribution: The Swamp Spanish Oak, a tree of rich bottomlands, ranges from Virginia southward to Florida and westward to Arkansas and Missouri. In Illinois, it is confined to the southern part of the State; but there, though apparently less widely distributed than the Spanish Oak, it is a much more important tree. According to Hall and Ingall's¹ report of 1911, it made up 20 per cent

of the bottomland stand in White County, 12 per cent in Franklin County, and 10 per cent in Hardin, Gallatin, and Saline counties. In these regions

¹ Ill. St. Lab. Nat. Hist. Bull. Vol. 9, Art. 4.



PLATE 37

QUERCUS RUBRA PAGODAEFOLIA ASHE SWAMP SPANISH OAK

it is associated especially with Pin Oak, Elm, and Black Gum, but it grows also with the Black, White, and Burr oaks, the Red Gum, and several other trees. Robert Ridgway reports the average measurements of 6 "Spanish Oaks" in the lower Wabash Valley as 120 feet high, $17\frac{1}{2}$ feet in circumference, and 58 to 59 feet in trunk length. He says that this tree is "the most symmetrical and stately of all our oaks; trunk straight and columnar and top massive and dense, reminding one in its appearance of the pecan. A more usual size is 150 feet high, the trunk fifty feet long and 15 feet in circumference four feet from the base."

During recent years, the largest tree seen has been only 100 feet high and 34 inches in diameter, but in the virgin bottomland forests this oak is still capable of yielding some 1500 board feet per acre.

Uses: The light reddish-brown wood of the Swamp Spanish Oak is made into lumber, and for this purpose it is valued nearly as highly as the wood of the White Oak.

QUERCUS MARILANDICA MUENCHHAUSEN

Black Jack

Scrub Oak

The Black Jack, commonly called Scrub Oak in Illinois, is a small tree with an open, narrow, round-topped crown of drooping branches. The thick and leathery, dark-green leaves, yellow-green beneath, are characteristically 3-lobed, but the lobes, which form the much-expanded top of the leaf, often are not cut out deeply. From the lateral lobes, the leaf blade slopes regularly to a narrow, rounded base. The leaves are 6 to 7 inches long and equally broad. The staminate catkins are 2 to 4 inches long; and the pistillate flowers, often in pairs, stand on the ends of short, rusty-woolly pedicels. The light-brown acorns about $\frac{3}{4}$ inch long, are buried for $\frac{1}{3}$ to $\frac{2}{3}$ of their length in deep, reddish-brown, stalked cups, the upper scales of which form a thick rim around its inner surface. The stout, gray to brown branchlets bear pointed, prominently angled buds, which are covered by rusty-haired scales. The dark-brown to black bark, which is deeply fissured into square plates 1 to 3 inches long, covers small trunks, which seldom exceed a diameter of 12 inches. The usual height of the tree is from 20 to 40 feet.

Distribution: The Black Jack is a tree of sandy and clayey barren lands. It ranges from New York into Florida and westward into Illinois, Arkansas, and Texas. In Illinois, it is found throughout a large part of the State on sterile soils, sands, and waste lands. Its most north-



PLATE 38

QUERCUS MARILANDICA MUENCHHAUSEN

BLACK JACK

ern stations are in Henderson and Woodford counties, but southward it becomes a common tree. Its associates are commonly the Black, Burr, and Post oaks, hickories, and Sassafras. In the southern counties, it is most frequently seen on the light gray silt loam soils that are underlaid by tight clay—situations commonly called post oak flats—and, according to Hall and Ingall¹ the Post Oak, which normally is most abundant, is outnumbered by the Black Jack where fires have occurred. Vestal² also



FIG. 47. Distribution of the Black Jack.

reports that, in the succession from bunch grass to forest on the sands of Mason County, it and the Black Oak are among the first to become established on the dry sand ridges.

There is a considerable difference between the leaves of the Black Jack in the northern and the southern part of the State. On the sandy plains in Henderson County, about Oquawka, its leaves are 3-lobed and not very velvety beneath, except for the petioles and veins. But southward, the leaves are often 5-lobed and almost felty beneath.

Uses: The rich-brown wood of the Black Jack, though heavy, hard, and strong, has but little commercial value, for the tree does not attain any considerable size and the wood is not sufficiently durable in the soil to make good fence posts. Its chief uses are as fuel and in the manufacture of charcoal. Nevertheless,

there are now about 90,000 acres of sandy soils wooded with Scrub Oak, and the preservation of these stands is justified by the ability of the trees to prevent the drifting of sands onto neighboring fields. In these situations Scrub Oak, or Black Jack, constitutes between 25 and 26 per cent of the stand, but it attains no great size, the largest tree measured being 42 feet high and 15 inches in diameter, in comparison with the average 50-foot height of Black Oak in the same situations.

¹ Bul. Ill. St. Lab. Nat. Hist. Vol. 9, Art. 4. 1911.

² Bul. Ill. St. Lab. Nat. Hist. Vol. 10, Art. 1. 1913.

QUERCUS PHELLOS LINNAEUS

Willow Oak

The Willow Oak is a moderate to large tree, with small branches which form an open, rather narrow crown. The light-green, shiny leaves, the blades of which are not lobed, measure $2\frac{1}{2}$ to 5 inches long by $\frac{1}{2}$ to 1 inch wide and usually are smooth beneath. Their petioles are only about $\frac{1}{8}$ or $\frac{1}{4}$ inch long. The loosely flowered staminate catkins are 2 or 3 inches long; and the pistillate flowers stand, alone or in pairs, on slender, smooth pedicels. The yellow-brown, pale-hairy acorns, which are almost hemispherical and $\frac{3}{8}$ to $\frac{1}{2}$ inch long, stand in rather shallow, somewhat woolly cups. The stout, reddish-brown twigs bear sharply pointed, chestnut-brown buds about $\frac{1}{8}$ inch long. The trunk, which usually has a diameter of about 2 feet, is covered by thin, smooth, brown bark, which eventually divides by narrow fissures into irregular plates. The usual height of the tree is 70 to 80 feet.

Distribution: Inhabiting the wet borders of streams and swamps, the Willow Oak ranges from southern New York into Florida and westward to Texas and Illinois. It is, however, a rare tree in Illinois, being found only in the four southernmost counties. Its occurrence in Pope and Massac counties is reported by C. S. Sargent, and E. J. Palmer has collected specimens of it in Alexander County. It has been found by C. J. Telford in Pulaski County also, on the bottomlands of the Cache River, where it is associated as an occasional tree with the Pin and Shingle oaks, the Sweet Gum, Soft Maple, and Elm. Henry Engelmann, the geologist, writes¹ that in 1866 he "found several north of Brooklyn," in Pope County, "in a wet flat, along with post oak, water oak, Spanish oak, laurel oak, black oak, barren hickory, scaly-bark hickory, sweet gum, and similar trees."



FIG. 48. Distribution of the Willow Oak.

¹ Geology of Illinois, Vol. 1, p. 433.



PLATE 39

QUERCUS PHELLOS LINNAEUS

WILLOW OAK



PLATE 40

QUERCUS IMBRICARIA MICHAUX

SHINGLE OAK

Uses: The heavy and rather coarse-grained wood of the Willow Oak is strong, though not hard, and is used in North Carolina for railroad ties, bridge planks, and general rough construction. In Illinois, the tree is so rare that it has no commercial value.

QUERCUS IMBRICARIA MICHAUX

Shingle Oak

Laurel Oak

The Shingle Oak is a tree of moderate size, with a long, clear bole from which the slender, horizontal branches grow to form a narrow, round-topped head. The thin, dark-green, shiny leaves, 4 to 6 inches long by 1 to 2 inches wide, have entire, or rarely somewhat 3-lobed,



FIG. 49. Distribution of the Shingle Oak.

blades covered with hair beneath. The stout, hairy petioles are about $\frac{1}{2}$ inch long. The white-woolly staminate catkins are 2 or 3 inches long; and the pistillate flowers stand on slender, woolly pedicels. The dark chestnut-brown acorns, $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter, are buried for about $\frac{1}{3}$ of their length in a thin cup, which is supported by a stout stalk often $\frac{1}{2}$ inch long. The slender, light-brown branchlets bear somewhat angled, light-brown buds about $\frac{1}{8}$ inch long. The trunk, which is covered by light-brown, shallowly fissured, broad-ridged bark, becomes 2 or 3 feet in diameter, and the tree attains a height of 50 feet or more.

Distribution: The Shingle Oak, which is a tree of rich hillsides and stream bottomlands, ranges from Pennsylvania westward into Iowa and southward into Georgia and Arkansas. It is to be found practically throughout

Uses: The heavy, rather close-grained, and hard wood of the Shingle Oak often is used for clapboards and shingles, but the trees which are cut in southern Illinois are sold as black oak for the furniture and veneer trade.

QUERCUS MACROCARPA MICHAUX

Burr Oak

Mossy Cup Oak

The Burr Oak is one of the largest oaks. Its massive, spreading limbs arise at a considerable height from the ground and form a broad open crown. Its thick and lustrous leaves, 6 to 12 inches long by 3 to 6 inches wide, have deeply 5- to 7-lobed, characteristic blades, covered with soft pale hair beneath, which expand from a wedge-shaped base to the very large and wavy-toothed end lobe. The rather sparsely flowered staminate catkins are 4 to 6 inches long, and the solitary or paired pistillate flowers stand on short or long woolly pedicels. The chestnut-brown acorns, which are finely hairy at the top and often 2 inches long, are buried to half their length or more in a deep, bowl-shaped cup whose upper scales are prolonged into a distinct mossy fringe. The stout, pale-orange twigs, which develop into dark-brown, often corky-winged branchlets, bear pale-brown, oval, hairy buds $\frac{1}{8}$ to $\frac{1}{4}$ inch long. The trunk, which is covered by pale-brown, deeply furrowed, plated bark, attains a diameter of 4 feet or more, and the tree is often more than 100 feet high.



FIG. 50. A large Burr Oak in Union County.

Distribution: Inhabiting the deep, moist soils of bottomlands and swales, the Burr Oak ranges from Nova Scotia westward into Manitoba and Montana and southward to Pennsylvania, Tennessee, and Texas. In Illinois, it grows throughout the State, finding satisfactory conditions for growth on the sands of the north, in the gravelly moraines of the central part, and in the bottomlands not only of the south but of the north as well. According to G. D. Fuller¹, it is found commonly in the

¹ Trans. Ill. State Acad. Sci. Vol. 12, pp. 251-252. 1919.

upland oak and dry oak forests of La Salle and adjoining counties, where it is associated with such trees as the Red, White, and Black oaks and hickory. It occurs also in the bottomland forests of the same region with Black Walnut, Black and Green ashes, Bass Wood, and others.

In the northern parts of Illinois, it has a short bole, which often makes but one good log length; but in the bottomlands of southern Illinois it towers massively above the other trees. The photograph, Figure 50, shows a tree 220 years old, on the Spann tract near Ware,

Union County, which when measured in 1924 had a height of 121 feet, a crown 63 feet wide and a trunk circumference of 15 feet. The bole had a log length of 55 feet and a lumber content of 5,000 board feet. A standing but dead tree three miles east of Belle Prairie, Hamilton County, had a height of 90 feet and a trunk circumference of 17 feet.

The largest living tree that has been measured in Illinois is a Burr Oak in Brownfield Woods near Urbana, which has a height of 104 feet and is 15 feet and 9 inches in circumference 4½ feet above the ground.

Uses: The close-grained, tough wood of the Burr Oak, which is hard and heavy, strong and very durable, is put to a great variety of uses, which range from fuel to ship building and cabinet making. In durability and strength, it ranks with white oak and is seldom separated from it on the market.



FIG. 51. Distribution of the Burr Oak.

In the Cypress forests of southern Illinois, Burr Oak constitutes only a very small part of the stand, but it is a little more common in the mixed hardwood forests of the main streams and is most abundant in the upland mixed hardwood forests. But nowhere in the State does it become an important lumber tree.



PLATE 41

QUERCUS MACROCARPA MICHAUX

BURR OAK

QUERCUS LYRATA WALTER

Overcup Oak

Swamp White Oak

The Overcup Oak is a tree of rather more than medium size, with a bole that splits, 15 feet or so above the ground, into rather small and somewhat drooping branches which form a fine, round-topped crown. The deeply or shallowly 5- to 9-lobed leaves, 7 to 10 inches long by 1 to 4



FIG. 52. Distribution of the Overcup Oak.

Distribution: Through river swamps and wet bottomland hollows, the Overcup Oak ranges from New Jersey to Florida and westward to Missouri and Texas. In Illinois, it is confined to the southern third of the State, where, though relatively rare, it is one of the characteristic trees of the bottomland Cypress forests of the Cache River, especially on the better-drained parts of the overflowed land, and of the Mississippi bottomland in Union County.

Uses: The wood of the Overcup Oak is very durable in the soil and is, in general, very similar to the wood of the White Oak, with which it is sold without commercial distinction. It is not commercially important in Illinois.

inches wide, are thin but firm, dark-green and smooth above and green and more or less hairy or velvety beneath. Their petioles are $\frac{1}{4}$ to 1 inch long. The hairy staminate catkins are from 4 to 6 inches long; and the pistillate flowers stand alone or in pairs, either sessile or on stalks thickly covered with pale, short hair. The globular, light-brown acorn $\frac{1}{2}$ to 1 inch long, is almost completely buried in a deep, spherical cup which stands on a slender, hairy stalk sometimes $1\frac{1}{2}$ inches long. The edge of the cup is thin and often irregularly split. The slender, orange or gray-brown twigs bear pale-brown buds about $\frac{1}{8}$ inch long, the scales of which are more or less hairy. The trunk, which is seldom more than 2 feet in diameter, is clothed by red-tinted gray bark, which is broken into thick plates. The usual height of the tree is from 60 feet up.



PLATE 42

QUERCUS LYRATA WALTER

OVERCUP OAK

QUERCUS STELLATA WANGENHEIM

Post Oak

The Post Oak is a tree of only moderate height, with a broad crown of stout, dense branches. The deeply 5-lobed leaves, 4 to 5 inches long by 3 to 4 inches wide, are thick, dark-green above, and covered beneath by velvety hair. Their stout petioles are from $\frac{1}{2}$ to 1 inch long. The

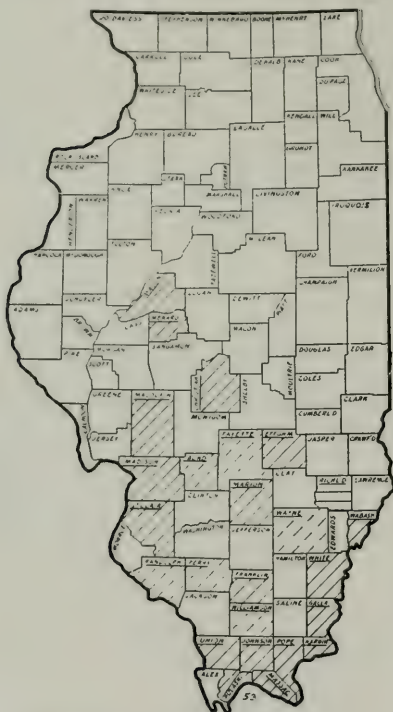


FIG. 53. Distribution of the Post Oak.

staminate catkins are 3 or 4 inches long, and the pistillate flowers stand alone on very short stalks. The light-brown, hairy-tipped acorns, $\frac{1}{2}$ to 1 inch long, are, for about $\frac{1}{3}$ of their length, held within fairly deep cups, which are sessile or short-stalked. The stout, orange, velvety twigs bear oval buds $\frac{1}{8}$ to $\frac{1}{4}$ inch long, which are covered by bright, brown, hairy scales. The trunk, which is seldom over $1\frac{1}{2}$ feet in diameter, is covered by red-brown, deeply fissured, broad-ridged bark. The tree, in age, usually attains a height of 50 or 60 feet.

Distribution: The Post Oak ranges from Massachusetts southward to Florida and westward to Mississippi and Iowa. In Illinois, it is a common oak of the uplands from Mason county southward, and throughout this region it is found on light-gray silt-loam soils underlaid by tight clay, where it forms characteristic "Post Oak flats."

Where the conditions are uniform, Post Oak forms pure stands; but the poorly formed trees have short, rapidly tapering trunks. On the poorest soils, it is mixed with Black Jack; on better soils, it grows with Black and White oaks and hickory; and if the ground is wet, there may be Pin and Shingle oaks also. In southern Illinois, its most common associates have been observed to be the Black and Scrub oaks and hickory, with Swamp Spanish, White, Schneck's, Pin, Burr, and Shingle oaks, as well as Ash, Elm, and Sycamore less common.

Post Oak grows very slowly—probably more slowly than any other tree in Illinois—producing not over 16 cubic feet per acre annually. The



PLATE 43

QUERCUS STELLATA WANGENHEIM

POST OAK

largest tree found in this State was 70 feet high and 25 inches in diameter. Trees 55 feet high and 12 to 14 inches in diameter are usually 100 years old, and trees which have attained a height of 65 feet and a diameter of 30 inches may be as old as 300 years.

Uses: The hard, close-grained wood of the Post Oak is very heavy and is durable in the soil. Though sometimes employed in rough construction, in cooperage, and in carriage-making, it is used chiefly for fuel, fence posts, railroad ties, and mine props.

The Post Oak flats, though stocked with a considerable number of trees per acre, do not yield any considerable amount of lumber. When the trees are cut for fence posts and mine props, they barely pay the taxes on the land; and when they are cut into cordwood, they do not even do this.



FIG. 54. Virgin stand of Post Oak on uplands in Perry County. The smaller trees are as much as a century old, and the larger trees three centuries.



PLATE 44

QUERCUS ALBA LINNAEUS

WHITE OAK

QUERCUS ALBA LINNAEUS

White Oak

The White Oak is a moderately large tree, with a tall, clear bole and a narrow crown of stout branches. The thin, bright-green leaves, 5 to 9 inches long by 2 to 4 inches wide, have shallowly or deeply 7- to 9-lobed blades which, though paler, are not hairy beneath. The stout petioles are

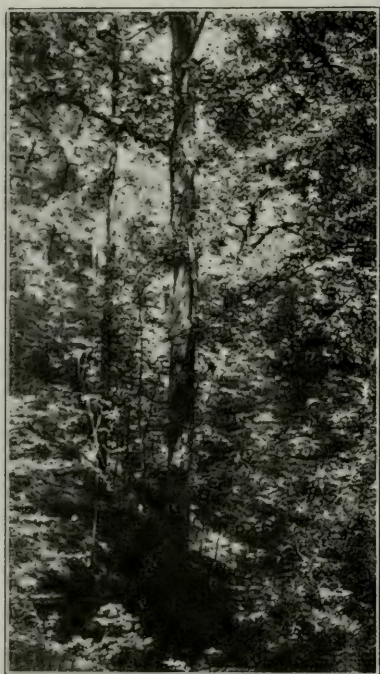


FIG. 55. White Oak in a ravine near Alto Pass. Photo by H. H. Chapman.

smooth and $\frac{1}{2}$ to 1 inch long. The staminate catkins are $2\frac{1}{2}$ to 3 inches long; and the bright-red pistillate flowers stand alone on very short stalks. The oval, light-brown, shiny acorns, $\frac{3}{4}$ inch long, stand in rather shallow cups, which are either sessile or provided with stalks 1 or 2 inches long. The red or gray twigs bear dark reddish-brown buds about $\frac{1}{8}$ inch long. The trunk, ordinarily 2 or 3 feet in diameter, is covered by light-gray to nearly white bark, which is divided by shallow fissures into long, irregular, thin scales. The tree is usually 60 to 80 feet high.

Distribution: The White Oak ranges, in a great variety of habitats, from Maine southwestward to Nebraska and southward to Florida and Texas. In Illinois, it has been found by collectors and foresters in 54 counties and undoubtedly occurs throughout the State. It often grows in pure stands of some extent, on rolling up-

lands and in ravines, dipping from them into the valleys, where it mixes gradually with other species, such as Beech, Tulip Tree, and Red Gum. The tallest and straightest trees, most suitable for sawlogs, piling, and railroad ties, are found on the sides of ravines. In the grazed woodlots of the northern and central counties, it often grows to a large size; but though the crown of heavy limbs may be immense, the bole is short and not of great value. In the upland timber of Union County, in the neighborhood of Jonesboro and Alto Pass, the White Oak constitutes from 20 to 23 per cent of the stand; on the western bluffs, from St. Clair

County northward, it constitutes 34 per cent; and it makes up about 48 per cent of the trees in the woodlots in the central and northern counties. In the Kaskaskia bottoms, between 17 and 18 per cent of the trees are White Oak, while in the adjoining bottoms of the secondary streams 15 per cent are White Oaks. The forest along the Big Muddy River is between 5 and 6 per cent White Oak; but the tree is not common along the large rivers in the north nor on the sterile sands and acid soils favored by the Post Oak. Its most common associates have been found to be Black Oak, hickory, Elm, ashes, Wild Black Cherry, Walnut, Hard Maple, Red Oak, Honey Locust, Bass Wood, and Sycamore, in about the order given, with Shingle Oak, Black Jack, Red Gum, Mulberry, and Hackberry less frequent.

The White Oak reaches its greatest size in the southern counties. The largest tree measured in our survey was 130 feet tall and 40 inches in diameter; and there are still fine trees, like the one shown in Figure 55, growing in the ravines of Union County.

The original White Oaks of the Wabash Valley also attained a great size. Ridgway gives the average height of 6 trees as 115 feet, the clear length of the bole as 48 feet 4 inches, and the circumference as 14 feet 9 inches. As compared with other species, such as the Red and Pin oaks, the White Oak grows slowly; but in its stands the trees are of many ages, and occasional trees can be cut to supply the demands of the market without destroying the forest.

Uses: The strong, close-grained, light-brown wood of the White Oak ranks highest among the oak woods for its technical qualities. It is hard, very heavy, tough, and durable; and as it is suitable for such a wide variety of uses, ranging from fuel and fence posts to ship-building and cabinet work, that the supply is not sufficient for the demand, efforts are being made constantly to substitute for it the inferior woods of the black oak class.

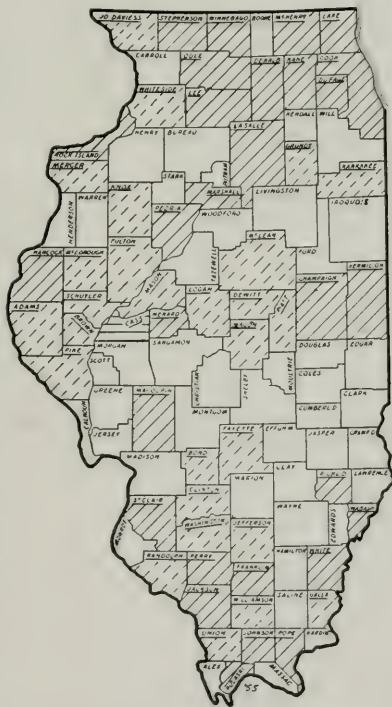


FIG. 56. Distribution of the White Oak.

In the early days, a large amount of white oak was made into heading and staves for oaken barrels; but most of the stave mills have disappeared. It is used extensively for fence posts, rural line telephone poles, rough construction, and bridge planking, and it is a leading wood for furniture, interior finishing of houses, railroad car construction, and wagon making. Some of the best logs go also into the manufacture of high-grade veneer.

The getting out of ship timbers was a flourishing industry at Mt. Carmel about 1885, as is attested by a photograph, given us by Robert Ridgway, which shows the loading of flat cars with squared white oak timbers destined for the British Navy. As an indication of the excellence of the early Wabash Valley White Oak, Mr. Ridgway reports a log 60 feet long which, when squared, was 36 inches wide.

White oak logs are used also for piles; and, according to the best estimates we can obtain, about one-third of the piling produced in Illinois is of this kind.

QUERCUS BICOLOR WILLDENOW

Swamp White Oak

The Swamp White Oak is a tree of somewhat more than medium size, with a narrow, open crown of rather small branches, those lower down usually somewhat drooping. The thick, firm leaves, 5 to 6 inches long by 2 to 4 inches wide, have dark-green, shiny blades that are rather densely covered beneath with white hair and are usually very shallowly many-lobed or sinuate-toothed on their margins. The stout petioles are $\frac{1}{2}$ to $\frac{3}{4}$ inch long. The hairy staminate catkins are 3 to 4 inches long; and the pistillate flowers stand, 2 or more together, on long, hairy stalks. The chestnut-brown, hairy-tipped, oval acorns, $\frac{3}{4}$ to $1\frac{1}{4}$ inches long, usually in pairs on stalks $1\frac{1}{2}$ to 4 inches long, are immersed for about $\frac{1}{3}$ of their length in thick, rather deep cups, around the rims of which the scale-points often form a short fringe. The light-brown to yellowish twigs, from which the bark can be pulled in thin strips when they become older, bear blunt, oval buds $\frac{1}{8}$ to $\frac{1}{4}$ inch long. The trunk, which grows to a diameter of 2 feet, is covered by a thick, gray-brown bark deeply fissured into long flat ridges. The usual height of the tree is 60 to 70 feet.

Distribution: From southern Maine to Minnesota and southward to Georgia and Arkansas, the Swamp White Oak grows in moist, fertile soils along the borders of streams and swamps. In Illinois, it occurs in scattered counties throughout the State, except the northwest corner, and



PLATE 45

QUERCUS BICOLOR WILLDENOW

SWAMP WHITE OAK

very probably is more common than the map seems to indicate. In Cook and Lake counties, it is reported by Pepoon¹ as abundant on the moist flats. It is common also in similar habitats in the south. In the Cypress forest, 1 tree in 10 is Swamp White Oak; in the mixed hardwood forests of the main streams, about 1 tree in 200. In central Illinois, particularly in Logan, Champaign, and Vermilion counties, its common associates are



FIG. 57. Distribution of the Swamp White Oak.

Chinquapin and Red oaks, hickories, ashes, Elm; Hard Maple, Ohio Buckeye, Black Cherry, Bass Wood, Honey Locust, Black Walnut, Hackberry, and Kentucky Coffee Tree; but in the south, notably in Wayne and Pulaski counties, it grows with the Pin and Swamp Spanish oaks, hickories, ashes, Elm, and Red and Black gums.

The largest Swamp White Oak measured in Illinois was 80 feet high and 17 inches in diameter. Trees of this size have reached a very considerable age, for the average tree lives for about 140 years, while a maximum age of 400 years has been recorded.

Uses: The hard, strong wood of the Swamp White Oak, light-brown in the heart, is tough and as durable as that of the White Oak. It is employed for a variety of purposes, including fuel, fencing, house finishing, boat building, cooperage, and cabinet making.

In the better-drained virgin forests of our southern counties, there are about 16 Swamp White Oaks to the acre—the most abundant oak; but the yield is small, being only about 620 board feet per acre as compared to the 1400 board feet of the Pin Oak, of which there are only half as many trees to the acre.

¹ Flora of the Chicago Region, p. 278.

QUERCUS PRINUS LINNAEUS

Cow Oak

Basket Oak

The Cow Oak is a tree of moderate size and bulk, with stout, up-tilted branches which form a compact, narrow crown. The firm, dark-green, and lustrous leaves, 6 to 8 inches long by 3 to 5 inches wide, are pale or even silvery-hairy beneath, and their margins are regularly and coarsely toothed. The stout petioles are $\frac{1}{2}$ to $1\frac{1}{2}$ inches long. The slender staminate catkins are 3 or 4 inches long, and the pistillate flowers stand, 2 or more together, on short hairy stalks. The bright-brown, rather shiny, hairy-topped acorns, 1 to $1\frac{1}{2}$ inches long, are borne in thick and rather deep but flat-bottomed cups with coarse and distinct scales. The red- to orange-brown, stout twigs bear hairy buds about $\frac{1}{4}$ inch long, the scales of which are distinctly red-tinted. The trunk, which attains a diameter of 2 feet or more, is covered by gray bark, which separates into thin, red-tinted scales.

Distribution: The Cow Oak is an inhabitant of the overflow lands of swamps and rivers from New Jersey to Florida and westward to Texas and Missouri. In Illinois, it is distinctly a southern tree, but it grows occasionally in the central part of the State, as our records for Champaign and Hancock counties show. Its chief associates, as indicated by strip survey data in Champaign, Hamilton, Pulaski, and Perry counties, are the Red, Pin, Swamp Spanish, Burr, and Swamp White oaks, hickory, ash, Elm, and the Red and Black gums, in the order given. The largest Illinois tree measured was 95 feet high and had a trunk diameter of 23 inches.

Uses: The wood of the Cow Oak, seldom distinguished by the lumber trade from that of the White Oak, is close-grained and hard, as well as tough and durable in the soil. It is of a somewhat lighter brown than White Oak wood and generally has less conspicuous tangential bands of parenchyma fibers in the late wood (see page 306).



FIG. 58. Distribution of the Cow Oak.



PLATE 46

QUERCUS PRINUS LINNAEUS

BASKET OAK



· PLATE 47

QUERCUS MONTANA LINNAEUS

CHESTNUT OAK

It is used for lumber, shingles, barrel staves, veneer, for fuel and fence posts, and in the manufacture of baskets.

The Cow Oak is not an important timber tree in Illinois, except as it contributes to the general production of white oak lumber. In the upland type of forest it is rare, occurring only at the rate of 2 trees in approximately 290 acres; but in the bottomland forests it is a little more common, there being approximately 2 trees to 15 acres of Cypress forest and 8 trees in the same area of mixed hardwoods on main streams.

QUERCUS MONTANA LINNAEUS

Chestnut Oak

Rock Chestnut Oak

The Chestnut Oak is a tree of moderate size, with large limbs that spread from the trunk, at a height of 15 or 20 feet, to form a broad, open crown. The firm, leathery leaves, 4 to 9 inches long by $1\frac{1}{2}$ to 3 inches wide, are pale and finely hairy on the lower surface, and the blade is coarsely toothed. Their petioles are $\frac{1}{2}$ to 1 inch long. The staminate catkins are long and hairy; and the pistillate flowers stand 2 or more together, on stout, downy stalks. The oval, lustrous acorns, 1 to $1\frac{1}{2}$ inches long and usually less than 1 inch broad, are buried for about one-half their length in thin, deep cups, the scales of which appear grown together except at their tips. The orange- to red-brown twigs bear pointed, hairy-tipped, brown buds $\frac{1}{4}$ to $\frac{1}{2}$ inch long. The trunk, which is often 3 feet in diameter, is covered by dark-brown to nearly black bark fissured into broad, rounded ridges. The height of the tree varies from 20 or 30 up to 60 feet.

Distribution: The Chestnut Oak grows on hillsides and rocky banks from Maine to Georgia and westward to Mississippi. In Illinois, it is found in but one locality—the rocky sides of Atwood Ridge in Union County at elevations of 900 feet. This is of particular interest because it marks the most westerly occurrence of the tree. Before the discovery of this station in Illinois, the native Chestnut Oaks in the “knob” region in the central part of southern Indiana were thought to mark the north-western limit of the range of the species.

Uses: The close-grained, hard, heavy wood of the Chestnut Oak, though easily split, is very strong and tough and quite durable. Where the tree grows in abundance, the wood is used for general purposes of construction, as well as for fence posts and fire-wood. It is used also for the manufacture of cooperage, farm implements, and baskets.

QUERCUS MUEHLENBERGII ENGELMANN

Yellow Oak

Chinquapin Oak

The Yellow Oak, sometimes called also the Chinquapin Oak, is a tall tree, with a narrow, round-topped crown of small branches capping the tall, buttressed bole. The firm, yellow-green leaves, 4 to 7 inches long and 1 to 5 inches wide and pale or white-hairy beneath, have coarse but uniform teeth with incurved points, and stand on slender petioles $\frac{3}{4}$ to $1\frac{1}{2}$ inches long. The oval, chestnut-brown acorns, $\frac{1}{2}$ to 1 inch long, are half-buried in deep, brown cups covered with small, blunt scales. The light-orange to reddish-brown twigs bear pointed buds $\frac{1}{8}$ to $\frac{1}{4}$ inch long, the scales of which are white and papery on the margins. The trunk, often nearly 3 feet in diameter, is covered by thin bark, the surface of which is broken into loose, silvery scales. The tree is often 80 feet high.

Distribution: From Vermont and Massachusetts to Nebraska and southward to Georgia and Texas, the Yellow Oak grows on ridges, hills, and bottomlands. In Illinois it ranges throughout the State, being most abundant and generally of a larger size in the southern counties. The largest standing tree that has been measured is in Brownfield Woods, Champaign County; its height is 80 feet and its diameter 29 inches. In the Coffee Creek locality near Mt. Carmel, a tree measuring 93 feet in height and 24 inches in diameter within the bark was found to be 185 years old. It grew on a gray silt-loam soil in company with Burr and White oaks and hickories. In Champaign, Logan, and Vermilion counties, Yellow Oak is associated with Red Oak, hickories, ashes, Elm, Hard Maple, Ohio Buckeye, Wild Black Cherry, and a number of other trees.

Uses: The hard and close-grained wood of the Yellow Oak is heavy and strong and is, besides, durable in the soil, having a life of



FIG. 59. Distribution of the Yellow Oak.



PLATE 48

QUERCUS MUEHLENBERGII ENGLEMANN

YELLOW OAK

about 10 years when used untreated. The lumber is made into furniture and is used in the interior finishing of houses. Formerly, however, it was much used in the Wabash Valley by wagon makers, as its wood was considered tougher than white oak.

OTHER OAKS IN ILLINOIS

The Scarlet Oak, *Quercus coccinea* Muenchhausen, is known to occur rarely in southern Illinois. A specimen has been collected at Karnak, Pulaski County, by Professor William Trelease, and another at Cobden, Union County, by E. M. Wright. According to Pepoon¹, trees of this kind are common in dry woods north and west of Chicago; but Professor Trelease regards these trees as forms of *Quercus ellipsoidalis* Hill. A flowering specimen collected in 1919 by E. W. Mattoon in a woodlot near Camp Grant appears to be Scarlet Oak.

The oak hybrids are many, though the individual hybrid trees are widely scattered and rare. *Quercus* X *Leana* Nuttall, the hybrid of *Q. imbricaria* and *Q. velutina*, is the commonest in the northern regions of the State. Specimens have been taken from trees near Marley, Will County, in the Des Plaines valley by Agnes Chase; near Willow Springs, Cook County, by E. J. Hill; near Peoria, by Frederick Brendel; and from a tree in Fulton County by Wolf. In southern counties, the hybrid most often encountered is *Q. X tridentata* Engelmann, a cross between *Q. imbricaria* and *Q. marilandica*, specimens of which have been preserved from trees growing in Massac, Wabash, Richland, and Champaign counties. *Quercus* X *exacta* Trelease, produced by the crossing of *Q. imbricaria* and *Q. palustris*, has been found in Richland County by Robert Ridgway and in Wabash County by Jacob Schneck. *Quercus* X *runcinata* Engelmann, derived from *Q. borealis maxima* and *Q. imbricaria*, is also apparently a usual form in the south. Specimens show its occurrence in Richland and Wayne counties, and a reported hybrid of *Q. imbricaria* X *rubra*, which occurs near Rosiclare and Shawneetown, in Hardin and Gallatin counties respectively, probably is the same form. A hybrid of *Q. bicolor* X *lyrata* is reported from Pulaski County, in the neighborhood of Mound City; and *Q. X Schockiana* Dieck., from *Q. palustris* X *Phellos*, and *Q. X Fernowii* Trelease, from *Q. alba* X *stелlata*, are also within our State. *Quercus* X *Shuettei* Trelease, from *Q. alba* X *macrocarpa*, has been found in Richland County by Robert Ridgway; and Pepoon² states that *Q. alba* X *bicolor*, which is possibly *Q. X Jackiana* Schneider, is represented by a single tree at Highland Park.

¹ Flora of the Chicago Region, p. 279.

² Loc. cit.

ULMUS LINNAEUS**The Elms**Family **ULMACEAE**

Moderate to large, deciduous trees, with simple, alternate leaves arranged in 2 ranks on the twigs, the blades broad, unequal at the base, and toothed. Stamens and pistils in one flower, the flowers usually several together in stalked or stalkless groups. Fruit a small, winged capsule of a papery texture, within which is one small, flattened, dark-brown seed. The slender, zig-zag twigs, with small round pith, bear solitary, oval, obliquely set buds above nearly half-round, 2-ranked leaf-scars. There is no terminal bud; but the lateral buds are inclosed by a number of 2-ranked scales.

Ulmus, with its 20 species, ranges through the entire temperate and cold-temperate regions of the Northern Hemisphere, except for western North America, where it is absent. In North America there are six species. Among fossils which date to the Ice Age, eight different species of Elm have been recognized, and most of them, including the three most common of our four Illinois species, exist as living trees today.

KEY TO THE ILLINOIS ELMS

None of the branchlets with corky wings.....*U. americana* p. 156

Corky wings more or less evident on 2-year-old branchlets.

Twigs rough-hairy; inner bark mucilaginous or "slippery"....*U. fulva* p. 163

Twigs soft-hairy to smooth; inner bark not mucilaginous.

Buds hairy; wings usually 2, thin, high, and opposite....*U. alata* p. 162

Buds smooth; wings 1 to 4, low, thick, discontinuous....*U. racemosa* p. 159

ULMUS AMERICANA LINNAEUS**White Elm**

The White Elm, also commonly called American Elm, is a tall and bulky tree, with large, ascending limbs that form a very wide, spreading crown. The pointed, coarsely double-toothed leaves, 4 to 6 inches long by 1 to 3 inches wide, are dark-green and often rough on the upper surface but pale and usually soft-hairy beneath. The flowers grow in short-stalked bundles of 3 or 4, each on a slender, drooping pedicel sometimes 1 inch long; and the fruits, which ripen as the leaves unfold, are about $\frac{1}{2}$ inch long, the points of the hair-fringed wings bending inward and inclosing the notch between them. The reddish-brown, usually smooth twigs bear oval, slightly flattened buds about $\frac{1}{8}$ inch long, which are covered by light-brown, smooth scales. The trunk, which is covered



PLATE 49

ULMUS AMERICANA LINNAEUS

WHITE ELM

of yielding about 6500 board feet per acre, which is about 3000 board feet more than either the Soft Maple or Red Gum can furnish; while on better-drained ground 3 trees per acre yield about 480 board feet, as compared to 6800 board feet from the Red Gum. In the Wabash region, the White Elm yield is only 92 board feet per acre, but in the Rock River region it is high, being estimated at about 5300 board feet per acre.

ULMUS RACEMOSA THOMAS

Rock Elm

Cork Elm

The Rock Elm is a moderately tall tree, with a long, straight bole from which short, stout branches spread to form a narrow, round-topped crown. The pointed, coarsely double-toothed, firm leaves, 2 to 2½ inches long by ¾ to 1 inch wide, are dark-green and shiny above but pale and soft-hairy beneath. The slender-pediceled flowers stand in groups of 2 to 4 along the axes of floral stalks up to 2 inches long. The oval, pale-hairy fruit is about ½ inch long, with a shallow, open notch between the tips of its hair-fringed wings. The light reddish-brown twigs, eventually furnished with 3 or 4 irregular, thick, corky wings, bear pointed brown buds about ¼ inch long. The red-tinted, gray bark is deeply fissured into broad, flat ridges with scaly surfaces. The tree is usually 80 feet high or more and its trunk may be as much as 3 feet in diameter.

Distribution: From Quebec, Wisconsin, and Nebraska, the Rock Elm ranges southward, on limestone ridges, steep hillsides, gravelly soils, and glacial drift, to northern New Jersey, Ohio, and Indiana. In Illinois, it is an infrequent tree, probably limited to our most northern counties.*

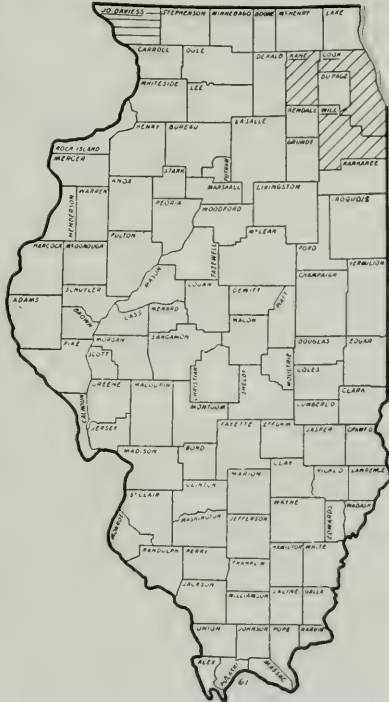


FIG. 61. Distribution of the Rock Elm.

* The record for Kane county is based on specimens collected by George A. Vasey in 1865, and that for Will County on a specimen collected by Agnes Chase in 1899. Specimens labeled *Ulmus racemosa*, and collected by Jacob Schneck from Johnson County, and by E. W. Mattoon at Olney, are regarded as *U. alata*. The occurrence marked for Jo. Daviess County is based on Pepoon's statement (see Trans. Ill. St. Acad. Sci. Vol. 3, p. 155. 1910).



PLATE 50

ULMUS RACEMOSA THOMAS

ROCK ELM



PLATE 51

ULMUS ALATA MICHAUX

WAHOO

Uses: The very tough and close-grained wood of the Rock Elm, light red-brown in the heart, is hard as well as strong and heavy. In its technical qualities, it is the finest of the elm woods, and it has in addition the special quality of resisting shocks and jars. As a consequence, it is used largely in agricultural implements, wheel hubs, building sills, and the framework of chairs. It is a fine wood for hockey sticks, which are subject to severe strains and twists, and it is made into plant-presses for botanists. When it can be seasoned without warping, it is one of the best woods for javelins.

ULMUS ALATA MICHAUX

Wahoo

Winged Elm

The Wahoo is usually a small to moderate tree, with a narrow, round-topped head of stout, straight branches. The somewhat sickle-shaped, coarsely double-toothed leaves, $1\frac{1}{2}$ to $3\frac{1}{4}$ inches long, are dark-green and smooth on the upper surface but pale and soft-hairy beneath. The stout,

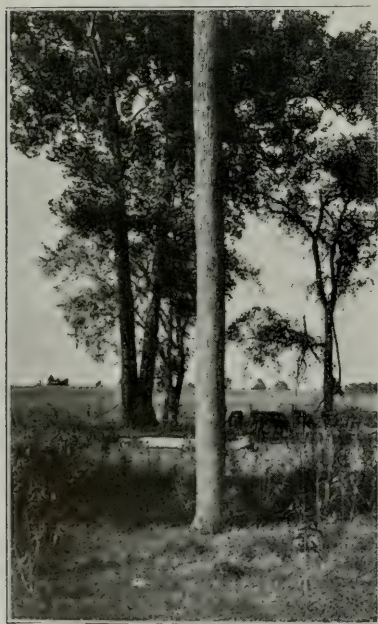


FIG. 62. Wahoo on the Gentry Creek bottoms of Richland County.
Photo by Robert Ridgway.

hairy petioles are about $\frac{1}{3}$ inch long. The flowers are in few-flowered fascicles; and the fruit, which is covered with long, white hairs, is about $\frac{1}{3}$ inch long, its base narrowed into a slender stalk and its tip capped by the two long, incurved wing-points. The smooth, reddish-brown twigs, which are marked by a few orange lenticels, become, during their first or second season, supplied with 2 oppositely placed, thin, corky wings. The pointed lateral buds, about $\frac{1}{8}$ inch long, are dark chestnut-brown. The red-tinted, brown bark, which incloses a trunk about 2 feet in diameter, is divided by shallow fissures into flat ridges. The tree usually attains a height of 40 or 50 feet.

Distribution: From Virginia westward to Missouri and southward to Florida and Texas, the Wahoo is to be found on gravelly uplands and occasionally along the borders of

swamps and streams. In Illinois, it is distinctly a southern tree, with a range generally south of the Kaskaskia River. There is a considerable variation in the development of the corky wings on twigs, which appears to be related to the situations in which the trees grow. On the low, moister places, the wings are less well developed, sometimes not appearing until after the twigs are 3 and 4 years old, and then sometimes having the appearance of the corky ridges of the Rock Elm. Specimens collected in Richland County by E. W. Mattoon and in Johnson County by Jacob Schneck are similar to the Rock Elm in this respect and have been labeled *Ulmus racemosa*; but by their buds and by other twig characters they are shown to be specimens of Wahoo. Thus, the natural ranges of the two trees, distinct throughout the United States, are found to be distinct in Illinois also.

Uses: Though the light-brown wood of the Wahoo is close-grained and hard, it is not very strong. But because it does not split easily, it is used for wheel-hubs and tool handles.

From the inner bark a rope is made, which is used for fastening the covers of cotton bales. The Wahoo is not, however, abundant enough in our southern forest to rank as a commercial tree.

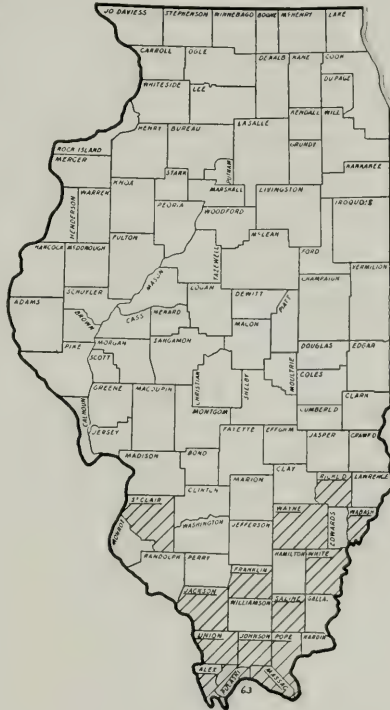


FIG. 63. Distribution of the Wahoo.

ULMUS FULVA MICHAUX

Slippery Elm

Red Elm

The Slippery Elm is a tree of only very moderate size, with an open and rather flat-topped crown of spreading branches. The slender-pointed, coarsely double-toothed leaves, 5 to 7 inches long by 2 to 3 inches wide, are dark-green and very rough to the touch above but pale and rather soft-hairy beneath. The stout, hairy petioles are about $\frac{1}{3}$ inch long. The crowded fascicles of flowers stand on very short pedicels. The round fruits, $\frac{1}{2}$ inch wide, have no hairs on the margins of the broad, thin wings.



FIG. 64. Distribution of Slippery Elm.

the tips of which are well united and leave no notch at the end of the seed capsule. The stout, light-brown branchlets, always quite conspicuously hairy on the new growth, bear blunt, oval buds about $\frac{1}{4}$ inch long above rather large, half-round, raised leaf-scars. The trunk, which is covered by red-tinted, dark-brown, shallowly fissured bark, attains a diameter of 2 feet; and the height of the mature trees is usually between 60 and 70 feet.

Distribution: From the St. Lawrence Valley, in Quebec, to South Dakota, the Slippery Elm ranges, on stream banks and rocky hills, southward to Florida and Texas. Though not a common tree in Illinois, it occurs in practically every part of the State. It is an occasional tree in the hardwood forests, making its best growth on fertile bottomland soils. In Wabash County, a tree was measured and found to be 89 feet high, with

a trunk diameter of 27 inches and a merchantable bole 48 feet long. The average trees on poorer land in other parts of the State are, however, much smaller.

Uses: The heavy and very close-grained wood of the Slippery Elm, dark-brown to red in the heart but lighter in the thin sapwood, is easily split but durable and serves well for fence posts and railroad ties. It is also hard and strong and it is used in making agricultural implements and wheel-hubs, as well as for the sills of buildings. A medical preparation made from the mucilaginous bark is used in the treatment of inflammations, such as boils and carbuncles.

Although not an abundant tree in the forests of Illinois, it is cut and made into lumber along with the White Elm, from which it usually is not distinguished.



PLATE 52

ULMUS FULVA MICHAUX

SLIPPERY ELM

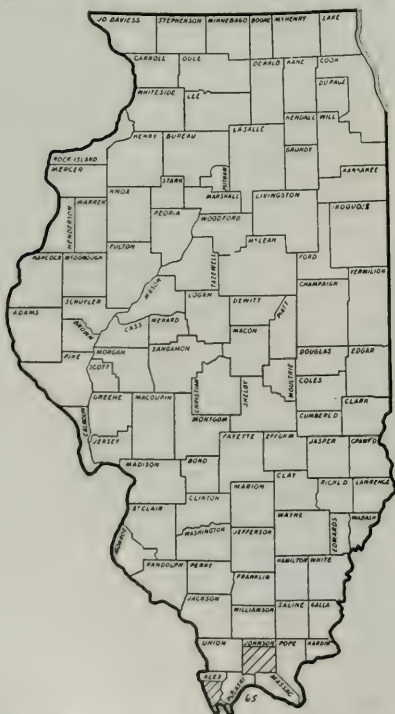
PLANERA GMELIN**Water Elm**Family **ULMACEAE**

Small, deciduous trees with alternate, 2-ranked, broad-bladed simple leaves. Flowers alike but functioning separately as staminate and pistillate flowers, the former borne in bundles on the year-old wood, the latter 1 to 3 together in axils of the new leaves. The fruit an oblong, prominently ribbed and tuberculate, light-brown drupe with a dark-brown to blackish, shiny, oval seed.

There is but a single species, which lives only in the southeastern United States, the sole living representative of an ancient genus, which appears, from its fossil forms, to have had a wide range in North America, Europe and Asia, during the geological epochs preceding and succeeding the Ice Age.

PLANERA AQUATICA GMELIN**Water Elm**

The Water Elm is a small tree, with a broad, low crown of slender, spreading branches. The dull-green, coarsely toothed, leathery leaves,



2 to 2½ inches long by ¾ to 1 inch wide, stand on slender, hairy petioles ⅛ to ¼ inch long. The flowers, borne at the same time as the leaves appear, stand on slender, erect pedicels, and the fruit, which is about ⅓ inch long, ripens in April. The hairy, brown branchlets bear fine, globular buds above nearly round leaf-scars. The trunk, which is covered by thin, brown to gray bark with large scales on the surface, may become 2 feet in diameter, and mature trees are usually 30 to 40 feet high.

Distribution: In swamps that are water-covered for several months of the year, the Water Elm ranges from North Carolina southward into Florida, westward to Texas, and northward again to the lower valley of the Wabash River. In Illinois, it is a very rare tree and is known to us only through specimens collected by E. J.

FIG. 65. Distribution of Water Elm.



PLATE 53

PLANERA AQUATICA GMELIN

WATER ELM

Palmer at Cairo and in Johnson County. A specimen collected from Hancock County and originally identified as this tree proves to be spice-bush.

Uses: Though close-grained, the light-brown wood of the Water Elm is light as well as soft and weak. It is of little commercial value, not only because of its poor technical characteristics but also because the small trees yield but little salable wood.

CELTIS LINNAEUS

The Hackberries

Family ULMACEAE

Deciduous trees and shrubs, with broad-bladed, simple leaves. The pedicelled flowers on the season's new growth; the staminate flowers in fascicles at the base of the growth, the pistillate flowers solitary or a few together in the axils of the upper leaves. Fruit a globular drupe, with thin flesh and a bony inner shell surrounding the seed. Twigs rounded, slender, and more or less zigzag, with small white, round, closely chambered pith and with solitary, stalkless, oval buds covered by 2 or 4 two-ranked scales; the end bud absent.

With its 60 or more species, *Celtis* is widely distributed through the north temperate and tropical regions of the world. In North America there are 6 species of tree form, but of these only two occur in Illinois.

KEY TO THE ILLINOIS HACKBERRIES

- Leaves half as broad as long; berry stems half as long again as the petioles; buds about $\frac{1}{4}$ inch long.....*C. occidentalis* p. 169
Leaves one-third as broad as long; berry stems half as long as the petioles; buds up to $\frac{1}{8}$ inch long.....*C. laevigata* p. 171

CELTIS OCCIDENTALIS LINNAEUS**Hackberry****Sugarberry**

The Hackberry is a tree of only very moderate height, with a round-topped head of spreading or drooping branches. The sharply pointed and usually sharply toothed leaves, $2\frac{1}{2}$ to $3\frac{1}{2}$ inches long by $1\frac{1}{2}$ to 2 inches broad, are thin and somewhat hairy beneath on the midrib and veins, with petioles usually less than $\frac{1}{2}$ inch long. The flowers are not distinctive, but the dark-purple, globular fruits, about $\frac{1}{3}$ inch in diameter, have dark orange flesh and hang from stems $\frac{1}{2}$ to $\frac{3}{4}$ inch long. The slender, red-brown branchlets bear oval, flattened pointed buds about $\frac{1}{4}$ inch long, and the trunk, usually not over 2 feet in diameter, is covered by dark-brown bark roughened by irregular, wartlike excrescences or by long ridges. The tree is usually between 40 and 50 feet high.

Distribution: From New England to Virginia and westward to Nebraska and Kansas, the Hackberry is a fairly common tree on rocky hills and ridges, but it is not found often on low ground. It ranges over the entire State of Illinois. Excepting the Post Oak and Scrub Oak types of upland woods, all of our hardwood forests contain Hackberry. It is most abundant in the drainage basin of the Ohio River, and occurs commonly with Pin Oak, Elm, Honey Locust, Soft Maple, cottonwoods, Burr Oak, Ash, Red Gum, and hickories. In the northern part of the State, its commoner associates are Elm, Ash, maples, Walnut, Burr Oak, and Bass Wood. Vestal¹ describes a well-defined Elm-Hackberry forest in Cumberland County, in which also occur Honey Locust, Black Haw, and, in some places, Shingle Oak. He believes that, as the Hackberry seeds are readily dispersed to considerable distances, "these forests are of independent and comparatively recent origin in locally favorable spots in the prairie uplands."

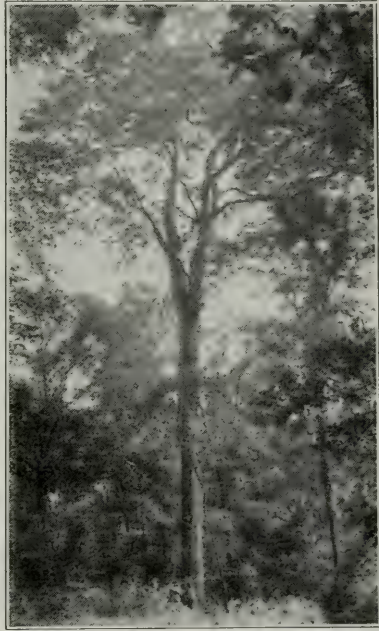


FIG. 66. A fine Hackberry in the upland woods at Allendale. This tree was 112 feet high and had a trunk diameter of 3 feet.

¹ Trans. Ill. St. Acad. Sci. 12:237. 1919.



PLATE 54

CELTIS OCCIDENTALIS LINNAEUS

HACKBERRY

In northern Illinois, at the present time, the Hackberry grows to a maximum height of 11 feet and a diameter of 1½ inches. In the extreme south it grows no taller; but in the Wabash Valley, the trees growing on rich bottoms are described by Robert Ridgway as very tall and beautiful, frequently attaining heights of 120 to 130 feet and diameters of 3 feet, with tall, straight boles, reaching 60, 70, and even 80 feet to the first limb.

Uses: The heavy, close-grained, light-yellow wood of the Hackberry is neither very strong nor very hard, but in durability it ranks with white elm. Unless it is carefully seasoned, it warps and twists; and so, beyond those of fencing and cheap furniture, it has few commercial uses.

As a source of lumber in Illinois, the Hackberry is of little importance. In the Cypress forests, there is about 1 tree to every 2 acres; in the mixed hardwood growths of the main streams, about 3 trees on every 2 acres; along secondary streams it is of no consequence at all; and in the upland hardwood forests, there are only about 15 trees to 100 acres. Along the Rock River, where the Hackberry numbers about 4 trees per acre, the yield is estimated at approximately 400 board feet to the acre.



FIG. 67. Distribution of the Hackberry.

CELTIS LAEVIGATA K. KOCH

Sugarberry

Mississippi Hackberry

The Sugarberry, also called the Mississippi Hackberry, is a tree of moderate size, with a broad crown of spreading or pendulous branches. The long and sharply pointed, thin leaves, $2\frac{1}{2}$ to 5 inches long by $\frac{3}{4}$ to $1\frac{1}{2}$ inches wide, are light-green on both surfaces, generally smooth above and below, and stand on slender, hairless petioles $\frac{1}{4}$ to $\frac{1}{2}$ inch long. The flowers terminate smooth, slender pedicels; and the orange-red to yellow fruits, $\frac{1}{4}$ inch in diameter, hang from the axils of the leaves on stems about as long as the petioles. The reddish-brown, shiny branchlets bear pointed, brown buds up to $\frac{1}{8}$ inch long. The trunk, inclosed by



PLATE 55

CELTIS LAEVIGATA K. Koch

SUGARBERRY

thin, pale-gray bark covered by prominent excrescences, attains a diameter of 2 feet or more; and the tree may become 60 to 80 feet high.

Distribution: The range of the Sugarberry extends from Virginia southward to the Everglades, westward to Texas and northward again into Illinois and Indiana. In Illinois, it is found on the bottomlands of the large rivers, and is limited in its distribution practically to the southern third of the State. Two specimens have been taken from Pike County, perhaps from the same tree, the locality given for them being on the Mississippi bottomland in the extreme northwest corner of the county. This represents, in comparison with our other records, not only the most northerly station for the tree but also a rather remarkable northward extension of its range.

In the Cache River bottomlands in Massac County, the Sugarberry grows with ash, Elm, Pin and Swamp Spanish oaks, Soft Maple, Red and Black gums, and hickory—a list which does not differ greatly from that of the Hackberry. In the Wabash Valley, a tree measured by Robert Ridgway was 60 feet high and 11 inches in diameter.



FIG. 68. Trunk and bark of the Sugarberry. Photo from the Field Museum of Natural History.

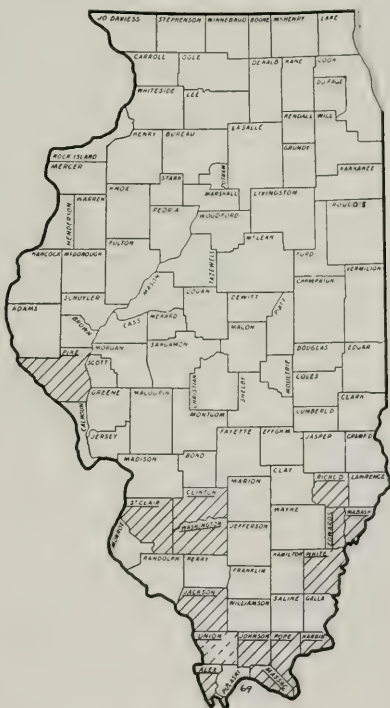


FIG. 69. Distribution of the Sugarberry.

Uses: The close-grained, light-yellow wood of the Sugarberry is neither strong nor hard and has but few commercial uses. In Illinois, it is not a common tree and, when cut, it is sold along with Hackberry, as the wood of the two trees is not distinguished in the lumber trade.

MORUS LINNAEUS

Mulberry

Family MORACEAE

Deciduous trees or shrubs, with simple, alternate, broad-bladed leaves, 3- to 5-nerved from the base. Staminate and pistillate flowers on different branches or even different trees, both in stalked clusters from the axils of bud scales or the lower leaves of the new growth; staminate flowers in long, cylindrical spikes, each with a 4-lobed calyx, 4 stamens opposite the lobes, and a rudimentary pistil; pistillate flowers sessile, in densely flowered, oblong spikes, each with a persistent, 4-lobed calyx, a flat, oval ovary capped by 2 spreading stigmas. Fruit a succulent "berry" composed of numerous tiny drupes developed from the individual flowers.

There are about nine species of *Morus*, and the genus ranges through the temperate regions of eastern North America, south along the highlands into South America, and from the southwest of Asia into Japan and the Indian Archipelago. There are two species in North America, one of which grows in Illinois.

MORUS RUBRA LINNAEUS

Red Mulberry

The Red Mulberry is a tree of moderate size, with a dense, round-topped head of stout, spreading branches. The entire, or often deeply 3-lobed, bluish-green, thin leaves, 3 to 5 inches long by $2\frac{1}{2}$ to 4 inches wide, are smooth or a little roughened above but pale and more or less hairy beneath, and have coarse, incurved teeth along their margins. The spikes of staminate flowers are narrow and 2 to $2\frac{1}{2}$ inches long, and the dense pistillate spikes, about 1 inch long, stand on short, hairy stalks. The sweet, juicy fruit, a little over an inch long, is at maturity nearly black. On the light, red-brown to orange, slender, zig-zag branchlets, the oval buds,



PLATE 56

MORUS RUBRA LINNAEUS

RED MULBERRY

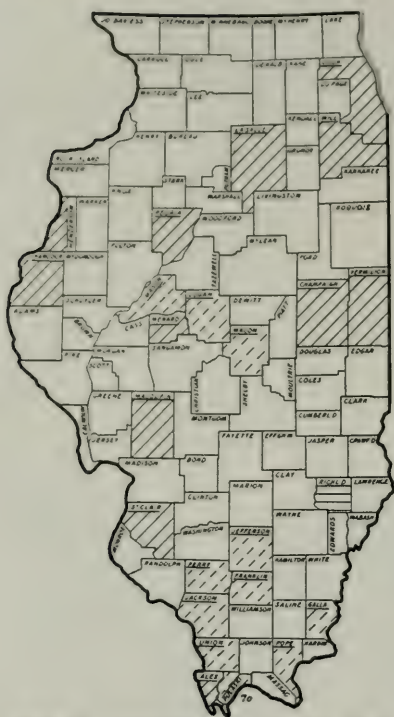


FIG. 70. Distribution of the Red Mulberry.

Spanish, and Cow oaks, together with hickory, Elm, ash, Hackberry, and numerous other trees, the particular mixture being determined by the location.

Before the Wabash region had been cut over for lumber, a tree measured by Jacob Schneck was found to have a height of 62 feet, a circumference of 10 feet 6 inches, and a bole reaching 20 feet to the first limb. The maximum height of Red Mulberry trees recently measured in a virgin stand of hardwoods in Union County was 30 feet, with an accompanying diameter of 7 inches.

Uses: The golden-brown wood of the Red Mulberry, which darkens with age and exposure, is soft and weak, though coarse-grained and tough. Because of its durability in the soil, the farmers of southern Illinois frequently reserve the mulberry trees when selling the other timber, in order to convert them into fence posts for their own use. Occasionally, the wood gets to the sawmills, and is cut into lumber for use in boat building and barrel making.

about $\frac{1}{4}$ inch long, stand above rather large and nearly circular leaf-scars. The trunk, which is covered by fairly thin, red-tinted, brown bark divided at the surface into elongated plates, may reach a diameter of 3 feet, and the mature tree is usually 60 to 70 feet high.

Distribution: The Red Mulberry ranges from Massachusetts westward into the Dakotas and southward to Florida and Texas. It grows throughout Illinois, being more numerous, and the individual trees larger, toward the south. In the northeast, as reported by Pepoon¹, it is "very local and rare or overlooked" along the Des-Plaines River. In Hancock County, Alice Kibbe says, the tree grows in rich woods, there being few large trees but many small ones. Usually the Red Mulberry grows alone or in small groups, in association with Black, White, Pin, Swamp White, Swamp

¹ Flora of the Chicago Region, p. 282.

MACLURA NUTTALL

Family MORACEAE

Deciduous, spiny trees, with alternate, broad-bladed, simple leaves. Staminate flowers with long pedicels, grouped on slender stalks which arise from the axils of the leaves; pistillate flowers sessile in dense, globular heads, which cap stout stalks arising from the axils of the new leaves. Fruit a large, globose, milky "orange" composed of the united fruits of the individual flowers. Twigs round, with axillary spines, round, pale pith, and small, globular buds which stand above somewhat triangular leaf scars.

There is but one species, the well-known Osage Orange. It is confined to eastern North America.

MACLURA POMIFERA SCHNEIDER

Osage Orange

Bow Wood

The Osage Orange is a tree somewhat over medium height, with an open, round-topped head of stout, uptilted, spreading branches. The sharply pointed, smooth-margined leaves, with blades 3 to 5 inches long by 2 to 3 inches wide, stand on slender petioles $1\frac{1}{2}$ to 2 inches long. The clusters of staminate flowers are 1 to $1\frac{1}{2}$ inches long, and the globular heads of pistillate flowers are $\frac{3}{4}$ to 1 inch in diameter. The globular, orange-like, green fruit, which ripens in the autumn, is 4 or 5 inches in diameter. The rather stout, pale-orange, zig-zag twigs bear pointed spines or small globular buds in the axils of the leaves. The trunk, which may attain a diameter of more than 2 feet, is covered by dark-orange bark deeply fissured into broad, rounded ridges. The height of the mature tree is between 50 and 60 feet.

Distribution: The Osage Orange has been planted widely as a hedge tree in all kinds of situations, but its natural habitat is the rich bottomland

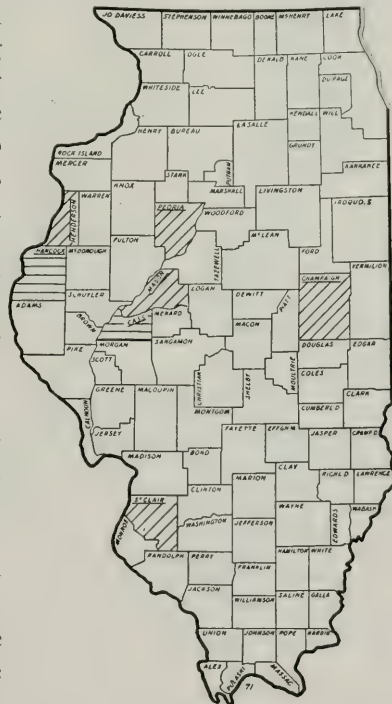


FIG. 71. Distribution of the Osage Orange.



PLATE 57

MACLURA POMIFERA SCHNEIDER

OSAGE ORANGE

of streams, and its native range extends from southern Arkansas and Oklahoma southward into Texas. In Illinois it is found occasionally as an "escape" from cultivation.

Uses: The bright, orange wood of the Osage Orange, though coarse-grained, is exceedingly hard and strong. Its durability in the soil exceeds that of all other woods used for fence posts and railroad ties. Fences of Osage Orange have stood for more than 50 years without a rotten post, while only 40 per cent of the posts in black ash fences remain sound for 10 years.

The Osage Indians called it "Bois d'arc," or bow-wood, and used it in their finest bows. It does not shrink with weather changes, and for this reason it was used in the early days to make the felloes of wagon wheels. At the present time, it finds some use in the manufacture of wooden machinery, insulator pins, and tool handles.

The bark of the roots contains an important dye, made up of moric and moritannic acids, which gives a yellow color; and the bark of the trunk, which yields the same substances, is employed in tanning leather.

MAGNOLIA LINNAEUS

Magnolia

Family MAGNOLIACEAE

Small to very large trees and shrubs, with deciduous or persistent, broad-bladed, alternate, and simple leaves. Flowers rather large and showy, consisting of 3 sepals, 6 to 12 petals in series of 3's, and numerous stamens and pistils with 2 recurved stigmas. Fruit a dry, cone-like structure, made up of numerous 2-seeded capsules, the seeds with thick, reddish, pulpy coats. The rather stout twigs, which contain large, round, sometimes diaphragmed pith, bear oval buds covered by a single scale. The bark is ashy-gray or brown and either smooth or scaly.

Represented by about 30 species, Magnolia is found in eastern North America and southern Mexico, and in eastern and southern Asia. But in the geological epochs succeeding the Ice Age, the number of species, judged from the fossils that have been found, must have been much larger. Certainly, the range of the genus was greater, for it is known to have been represented in southern Europe and Japan, as well as British Columbia, Alaska, and Greenland. At the present time there are in the United States 7 species, one of which is native to Illinois.

MAGNOLIA ACUMINATA LINNAEUS

Cucumber Tree

Mountain Magnolia

The Cucumber Tree is of moderate to large size, with a pyramidal crown of rather small, spreading or erect branches. The pointed, yellow-green leaves, 6 to 10 inches long by 4 to 6 inches wide, are smooth on the upper surface but paler and soft-hairy beneath. The slender and eventually smooth petioles are 1 to 1½ inches long. The flowers, which stand on pedicels ½ to ¾ inch long, have 3-pointed, reflexed, membranous sepals and 6 erect, greenish-yellow petals 2½ to 3 inches long. The oblong, sometimes curved, "cucumber-like" fruit is dark red and between 2 and 3 inches long. The bright red-brown branchlets are slender, with sharp-pointed and hairy terminal buds ½ to ¾ inch long—about thrice as long as the blunt lateral buds which are set in the curve of the narrow, moon-shaped leaf-scars. The trunk, which is clothed by thin, furrowed, dark-brown, scaly bark, becomes 3 or 4 feet in diameter; and the tree grows to a height of 60 to 90 feet.

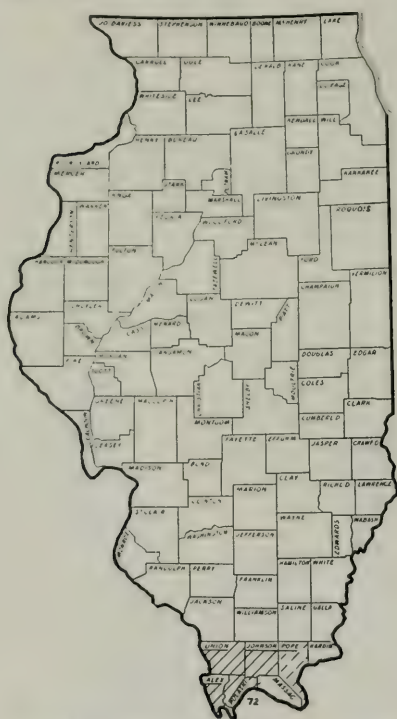


FIG. 72. Distribution of the Cucumber Tree.

ally smooth petioles are 1 to 1½ inches long. The flowers, which stand on pedicels ½ to ¾ inch long, have 3-pointed, reflexed, membranous sepals and 6 erect, greenish-yellow petals 2½ to 3 inches long. The oblong, sometimes curved, "cucumber-like" fruit is dark red and between 2 and 3 inches long. The bright red-brown branchlets are slender, with sharp-pointed and hairy terminal buds ½ to ¾ inch long—about thrice as long as the blunt lateral buds which are set in the curve of the narrow, moon-shaped leaf-scars. The trunk, which is clothed by thin, furrowed, dark-brown, scaly bark, becomes 3 or 4 feet in diameter; and the tree grows to a height of 60 to 90 feet.

Distribution: From Ontario to Georgia and westward to Louisiana and Missouri, the Cucumber Tree grows on hillsides, mountain slopes, and along streams. In Illinois, it is

native only in the extreme southern part of the State, where it is to be found as an occasional tree among other hardwoods on the richer and cooler northern slopes as well as on the bottomlands. In its moisture requirements, it is rather exacting, preferring deep, loose, moist soils and avoiding situations where the upper soil layers tend to become dry. Although it never forms pure stands, it makes up a considerable proportion of the new stand on the cut-over and partially drained bottomlands of Union County. Its common associates include the White, Pin, and Black oaks, Hickory, Black Gum, Beech, Ash, Tulip Tree, and numerous others, both on uplands and bottomlands.



PLATE 58

MAGNOLIA ACUMINATA LINNAEUS

CUCUMBER TREE

Uses: The yellow-brown wood of the Cucumber Tree, though close-grained, is neither hard nor strong; and though occasionally sawed into lumber for flooring and cabinet-making, it is used chiefly for veneers and carriage and automobile bodies—purposes for which its durability makes it suitable.

LIRIODENDRON LINNAEUS

Yellow Poplar

Family MAGNOLIACEAE

Very tall, deciduous trees, with alternate, broad-bladed, 4-lobed leaves with broad, notched tips. Flowers large and conspicuous, with 3 sepals, 6 petals, and numerous stamens and pistils, the latter developing together into a narrow, woody, cone-like fruit with 1 or 2 seeds in each of its capsules. The twigs are round and moderately thick, with light-brown, diaphragmed pith and flattened, 2-edged buds above nearly round leaf-scars. The brown bark is deeply furrowed and bitter.

At the present time, there are 2 species of *Liriodendron*, one native in eastern North America, the other in Central China; but in ancient geological times there existed a great variety of species, which flourished throughout most of the North Temperate Zone and even in Greenland and Iceland.

LIRIODENDRON TULIPIFERA LINNAEUS

Tulip Tree

Yellow Poplar

The Tulip Tree is exceedingly tall, rising at maturity to a height of 150 feet or more, and its straight bole is capped with a narrow, conical crown of rather small branches. The dark-green and shiny leaves, 5 to 6 inches long, equally broad, and pale on the lower surface, are variable in shape but have quite commonly 4 distinct, pointed lobes, the upper 2 lobes being so arranged as to give the leaf end a flat or notched appearance. The flowers, which are $1\frac{1}{2}$ to 2 inches deep, stand on slender pedicels nearly an inch long, the greenish-white sepals spread or turn downward and fall soon, and each of the 6 petals is conspicuously marked with orange at its base. The mature, cone-like fruit is from $2\frac{1}{2}$ to 3 inches long by about $\frac{1}{2}$ inch thick and ripens in September or October. The shiny, reddish-brown branchlets, which contain pale, diaphragmed pith, are terminated by a flat, 2-edged, and somewhat stalked bud about $\frac{1}{2}$ inch long, and the dark-red lateral buds, smaller than the terminal one, stand above large, round leaf-scars. The trunk, covered when young by thin, scaly bark but when old by deeply furrowed brown bark 2 inches thick, often attains a diameter of 5 feet or more.



PLATE 59

LIRIODENDRON TULIPIFERA LINNAEUS

TULIP TREE

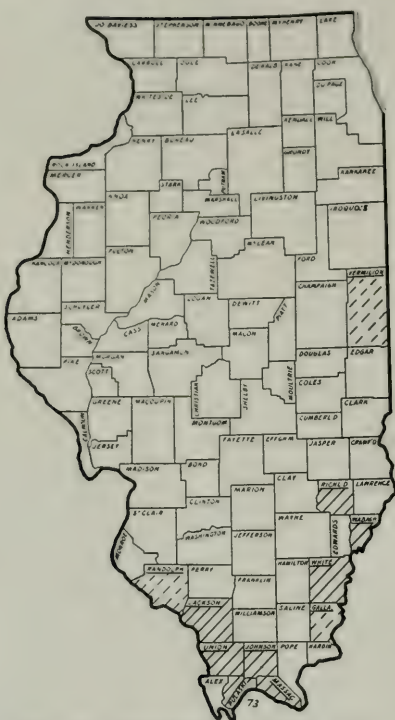


FIG. 73. Distribution of the Tulip Tree.

Distribution: On slopes and in stream valleys, but always on deep and moist but well-drained soils, the Tulip Tree ranges from Massachusetts south to Florida and westward to Missouri, Arkansas, and Louisiana. In Illinois, it is distinctly a southern tree, its range reaching northward in the west only as far as Piney Creek in St. Clair County and in the east to Richland County. Its occurrence in the southeast corner of Vermilion County is undoubtedly a local extension of its range in Indiana, where it is known to have been native in the north as well as in the south. In the southern Illinois counties which line the Mississippi, Ohio, and Wabash rivers, the Tulip Tree finds favorable sites on the deep, moist soils of cool ravines and along the lesser streams; but it does not venture far into the interior counties.

Its common associates are White, Black, and Red oaks, hickories, Sycamore, Black and Red gums, Beech, White and Slippery elms, the maples, ashes, and Black Walnut. In Pulaski County, it grows on the terraced soils of the bottomlands, just above the Cypress swamp, with Hard Maple, ashes, Bass Wood, hickories, and elms; and at the Piney Creek station, it grows with Beech, Black Gum, and Short-leaf Pine. About 65 years ago, A. H. Worthen¹ observed that "at points in Johnson County where sandstone does not prevail, the limestone and shales have added to the soil by their disintegration and this change of soil can be recognized by a somewhat changed growth of timber, especially by the presence of yellow poplar."

The original Tulip Trees of the Wabash Valley, according to Robert Ridgway², ranked next to the Sycamore in the size, height, and symmetry of their trunks. He measured 20 standing trees and found them to have an average height of 147 feet, a trunk circumference of 19 feet 4 inches, and a clear bole 69 feet long. He states, also, that "the finest

¹Geology of Illinois, Vol. 1, p. 377.

²American Naturalist, Vol. 6, pp. 658-665 and 724-732. 1872.

tree measured was one cut for lumber near Timberville . . which measured 158 feet in total length while the trunk was 23 feet in circumference 3 feet from the base, and 18 feet at a point 74 feet further up where the first branch grew. The trunk was perfectly sound and symmetrical throughout." The largest Tulip Tree measured in our recent forest survey was only 90 feet high, with a diameter of 27 inches.

Uses: The wood of the Tulip Tree, often called "whitewood" in the lumber trade because of its creamy-white sapwood, is yellowish-brown with a green tint in the heart. Being light and soft and easily worked, though somewhat brittle and weak, it finds numerous uses in the manufactured articles of commerce. Because of its durability and receptiveness to paint, it is used extensively in the exterior trim of houses, as in cornices, bevel siding, and veranda columns; and, though it has no decided grain pattern, the color contrast between its heart and sapwood lends a pleasing effect for interior finishing. Formerly, a considerable amount of yellow poplar was used in the manufacture of buggy boxes and wagon beds; but the present cut finds its way into automobile bodies, boats, shingles, drawing boards, tables, and veneers. It is an ideal wood for turnery, and much of it is used in making toys, novelties, and cabinets. Tulip Tree shavings, together with other waste wood, are shipped from St. Louis mills to Chillicothe, Ohio, to be made into paper pulp.

Though still valuable, the Tulip Tree no longer holds an important place among the commercial trees of our forests. In the bottomland forests, it grows only in the south; and there it is to be found only along the secondary streams at the rate of about 1 tree per acre. In the upland forest, it grows only with the mixed hardwoods, 1 tree to the acre on an average; but even when it is more numerous, as in the upland stands of Union County, it makes up only about 3 per cent of the stand. and even then only 1 tree in 3 has reached merchantable size, and the merchantable trees yield only 70 to 120 board feet to the acre.

ASIMINA ADANSON

Pawpaw

Family ANONACEAE

Deciduous small trees or shrubs, with alternate, broad-bladed, simple, and entire leaves. Flowers, borne alone on pedicels from the old leaf axils, have 3 green sepals, 6 dark petals in 2 series of 3 each, many stamens, and 3 to 15 pistils crowded in the center of the flower. The fruit is berry-like and edible. The round twigs contain white, green-diaphragmed pith, end in a naked terminal bud, and bear smaller lateral



PLATE 60

ASIMINA TRILOBA DUNAL

PAWPAW

Robert Ridgway¹ reported, in 1882, that he had seen pawpaws in the Wabash Valley with a height of 48 feet and a trunk circumference of 32 inches, but at the present time one seldom sees a tree more than 30 feet high and 24 or 27 inches in circumference.

Uses: The coarsely grained, spongy wood of the pawpaw, which is not only light but soft and weak as well, has no commercial value. The tree is used to some extent in decorative planting; but its chief value lies in its fruit, which matures about the middle of September. As its poor keeping qualities do not allow it to be shipped to fruit markets, its sale is limited to the localities in which it is grown. There are two varieties of fruits, one with white and one with yellow flesh, and it is the latter that is considered the more desirable for eating.

SASSAFRAS NEES

Sassafras

Family LAURACEAE

Small to moderate, deciduous trees, with alternate, simple, variously lobed leaves and terminal flower buds. The staminate and pistillate flowers on different trees, each usually in few-flowered racemes, and each flower with six sepals, no petals, 9 stamens (poorly developed in the pistillate flowers), and one ovary (absent in the staminate flowers). Fruit a dark blue to black berry, with thin flesh surrounding the dark brown seed. The rounded, green twigs contain white, somewhat angled pith and bear solitary, subglobose lateral and terminal buds above small, nearly semicircular leaf-scars. The bark red-brown, thick, and deeply furrowed.

With its 3 species, Sassafras now grows in southeastern North America, southeastern Asia, and Formosa; but in pre-glacial ages, several species, some of which had leaves quite similar to those of our one modern American form, were in existence, and the range of the genus included southern Europe, South America, Australia, Greenland, and northwestern North America.

¹ Proc. U. S. Nat. Museum, Vol. 5, pp. 49-88.

SASSAFRAS OFFICINALE NEES AND EBERMAIER

Sassafras

The Sassafras tree is generally of only very moderate size, with a flat-topped head of rather stout branches which extend almost horizontally from the trunk. The firm and often rather leathery, dark-green leaves, 4 to 6 inches long by 2 to 4 inches wide and more or less hairy beneath, commonly have 2 or 3 very distinct, large, and characteristic apical lobes. The petioles are from $\frac{3}{4}$ to $1\frac{1}{2}$ inches long. The small, greenish flowers stand on short stalks along a central axis and form racemes about 2 inches long. The blue berries, which ripen in the fall, are between $\frac{1}{4}$ and $\frac{1}{2}$ inch long and stand in scarlet cups at the tips of stalks $1\frac{1}{2}$ to 2 inches long. The bright-green, shiny branchlets bear globular buds about $\frac{1}{4}$ inch long. The trunk is generally not over 6 inches in diameter. The tree rises to an ordinary height of 30 or 40 feet; but much larger trees may be found.

Distribution: From Maine to Iowa and southward to Florida and Texas, Sassafras finds a natural home on rich and sandy, well-drained soils, often invading abandoned agricultural land. With the exception of our 3 northern tiers of counties, it ranges throughout Illinois, but it is most frequently met with to the south of the Illinois River. Though generally a small tree, it is known to have attained a height of 71 feet and a trunk circumference of over 7 feet, with a clear bole 52 feet 6 inches long, in the Wabash Valley. A tree standing 3 miles northwest of Maysville, Pike County, measured 33 inches in diameter but, being on open ground, it has a short trunk.

Sassafras sometimes grows in pure stands, as at Foley's Mill, near Paris, Edgar County; but it is usually accompanied by other trees. On poor or abandoned land, its associates often are Persimmon and Sumach; but on bottomlands, as in Wayne County, they are Red Gum, River Birch, hickories, ash, and Swamp White Oak. In Fulton County, it was found with hickories, Elm, Bass Wood, White and Shingle oaks, Wal-



FIG. 75. Largest Sassafras in Illinois. This tree, situated in Pike County, near Maysville, has a trunk diameter of 33 inches.



PLATE 61

SASSAFRAS OFFICINALE NEES & EBERMAIER

SASSAFRAS

nut, and Ironwood; in Kankakee County with the Black and White oaks and Black Cherry; and in Mason County with the Black, White and Jack oaks and Red Mulberry.

Uses: Though soft and light, the wood of the Sassafras, which is light-brown with a yellowish thin sapwood, is very durable in the soil and is used not only for fence posts and rails but also for railroad and mine ties. The roots furnish the material for sassafras tea, and sassafras oil, distilled from the bark, is an ingredient of certain medicines and perfumes.

In the Wabash Valley, where trees 80 feet high, though only 14 inches in diameter, have been seen, Sassafras furnishes about 30 board feet per acre, while among the upland timber of Union County, where the maximum height is 30 feet and the greatest diameter 8 inches, the board-foot yield is negligible.

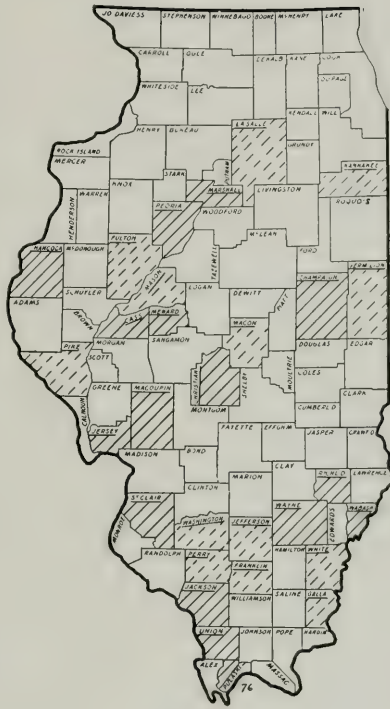


FIG. 76. Distribution of the Sassafras.

LIQUIDAMBAR LINNAEUS

Family HAMAMELIDACEAE

Tall, deciduous trees, with alternate, broad-bladed, palmately lobed leaves and flowers with rudimentary sepals and no petals. The staminate and pistillate flowers separate, the former in terminal racemes, the latter in globular heads at the ends of stalks arising from the axils of the upper leaves. Fruit a globular collection of capsules, armed by hardened and incurved, warty spines, usually containing a flattened, terminally winged seed.

The 4 species of this genus give it a disconnected range which includes southeastern North America and Central America, southeastern and southwestern Asia, and Formosa. But from fossils, about 20 species, now extinct, are known to have existed during the world's history and to have grown, at various times, in Asiatic Russia, southern Europe, western North America, and even Alaska and Greenland. There is now but one species in the United States.

LIQUIDAMBAR STYRACIFLUA LINNAEUS

Sweet Gum

The Sweet Gum is a tree of considerably more than moderate height, with a small and oblong crown of slender branches. The thin, bright-green, finely toothed leaves are divided into 5 or 7 large, pointed lobes, so that each leaf has the appearance of a star. The slender petioles are 5

or 6 inches long. The terminal racemes of staminate flowers are 2 or 3 inches long, the flowers being arranged in compact heads along the axis; and the pistillate flowers are grouped in globular heads $\frac{1}{2}$ inch in diameter on the ends of drooping pedicels. The globular fruits attain a diameter of 1 to $1\frac{1}{2}$ inches, the capsules opening in the autumn to set free brown, resinous, winged seeds about $\frac{1}{2}$ inch long. The round and often corky-ridged twigs contain brown, star-shaped pith and bear oval buds above more or less triangular leaf-scars. The trunk, covered by deeply furrowed, light-gray bark, attains a diameter of 4 feet or more; and the tree often grows to a height of 100 feet or over.

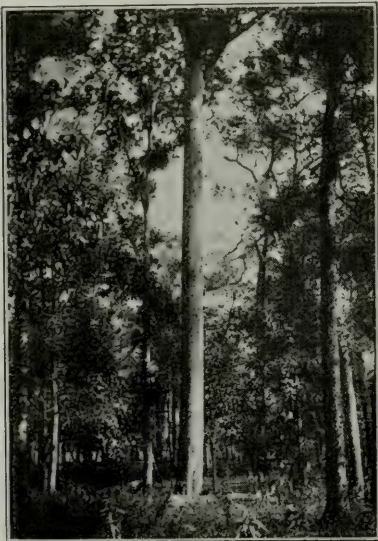


FIG. 77. A Sweet Gum in the forest near Mt. Carmel. This tree had a clear bole 78 feet long, a crown spread of 85 feet, and a trunk circumference of 12 feet 6 inches. Photo by U. S. Forest Service.

Distribution: On rich, inundated bottomlands and in swamps, the Sweet Gum ranges from Connecticut to Mis-

souri and to Florida, Texas, and Mexico. In Illinois, it is native only in the southern counties, coming up the Wabash and its tributaries to Richland County and up the Mississippi to Jackson County. Of all the trees in the virgin forests of the Wabash Valley, according to Robert Ridgway, Sweet Gum, or Red Gum as it is often called, had the tallest and straightest shaft, in proportion to its girth. The two largest specimens seen by him had trunks 17 feet in circumference, and one of these had a clear bole 80 feet long; and the tallest tree he saw cut for lumber had a total length of 164 feet. In our forest survey, we measured a Sweet Gum in Massac County, which had a height of 122 feet, a bole 62 feet long, and diameters of 34 inches at the base and 26 inches at the top of the bole.



PLATE 62

LIQUIDAMBAR STYRACIFLUA LINNAEUS

SWEET GUM

It furnished, when sawed, 2,317 feet of lumber for egg crates. A fine stand is now in existence on the Coffee Creek bottoms near Mt. Carmel, in which the trees vary from 22 to 31 inches in diameter and average about 115 feet in height.

On the bottomlands, the Sweet Gum is commonly associated with Sycamore, Cottonwood, Honey Locust, the bottomland oaks, Pecan, Hackberry, and Soft Maple.

Uses: The heavy and close-grained wood of the Sweet Gum, though hard, is not very strong; but because of its fine texture and the alternating streaks of red and black, which give highly figured patterns, it is used often for interior finishing, especially in the panels of doors and walls.

To some extent, it is used in the manufacture of furniture, as a substitute for walnut or mahogany, being, indeed, exported to England under the trade name "satin walnut."

A "sweet gum" derived from the tree is similar, in its properties and composition, to the storax taken from *Liquidambar orientalis* in Asia Minor, a substance yielding both cinnamic acid and cinnamic alcohol. These products enter into the manufacture of tobaccos, pharmaceutical substances, adhesives, and perfumes. Andre Michaux, in relating his travels between 1793 and 1796, says that "a Frenchman who traded among the Cheroquois savages cured himself of the itch by drinking for ten days a decoction of chips of that tree which he called copalm and which is the tree *Liquidambar*."



FIG. 78. Distribution of Sweet Gum.

In 1925, the Illinois cut of Sweet Gum yielded two and a half million board feet of lumber, and in addition a large amount went into the manufacture of basket and crate veneers. In the Cypress swamps, Sweet Gum is third among the trees in importance and constitutes between 10 and 11 per cent of the stand; among the hardwoods of the main streams, it constitutes between 4 and 5 per cent of the stand; but along the secondary streams, it falls to a low position among the timber trees. In the Wabash

Valley, there is still a potential yield in the virgin forest of 4,500 board feet to the acre, while in the Cypress swamps the yield is estimated at about 3,600 board feet per acre. Elsewhere, the Sweet Gum is not now of great importance as a timber tree.

PLATANUS LINNAEUS**Plane-tree**Family **PLATANACEAE**

Small to very large, deciduous trees, with alternate, broad-bladed, more or less distinctly lobed leaves, the petioles enlarged at the base and inclosing the buds. The minute flowers in dense, stalked heads, staminate and pistillate flowers common in separate heads, the former dark-red and the latter light-green. The staminate flowers with 3 to 6 small sepals, 3 to 6 pointed petals, and as many stamens as sepals; the pistillate flowers with 3 to 6 sepals and petals and an equal number both of rudimentary stamens and of pistils. Fruit a long-stalked, dense head of nutlets, within which are the light-brown seeds. The round, zig-zag, moderate-sized twigs contain pale to brownish pith and, though lacking a terminal bud, bear rather large, conical one-scaled lateral buds within the circular leaf-scars. Thin stipule scars encircle the twigs at each leaf-scar. The bark characteristically exfoliates in large, thin strips, exposing the white under bark.

With its 6 or 7 modern species, *Platanus* is now native in North America and southwestern Asia, as well as Mexico and Central America. But the history of the Plane-tree extends far back into the early story of the world's life. Not less than 16 species have been found among American fossils; and these records, which show that North America was the original home of the Sycamore, carry us back to a time when the ape-man was still a being of the future and when the gigantic dinosaurs still roamed the earth. Though of most ancient ancestry and once a widely distributed and numerous tribe, *Platanus* has succumbed to the march of the ages; and there are now but 3 species in North America, of which one alone is found in Illinois.

PLATANUS OCCIDENTALIS LINNAEUS**Sycamore****Buttonwood**

The Sycamore is an exceptionally tall tree, often with several trunks that rise from near the ground to a great height and then give out massive, spreading limbs, which form a very wide and open head. The 3- to 5-lobed, coarsely but sharply toothed leaves are thin but firm; the blade,



FIG. 79. Sycamore grove on the Mississippi bottoms in Union County.

4 to 7 inches long and almost equally broad, is bright green on top, though paler beneath, where the midrib and veins are furnished with fine hair. The stout petioles are between 3 and 5 inches long. The flower heads are solitary, or occasionally 2 together, on the ends of pendulous, pale-hairy pedicels; and the fruits or "button-balls", which develop from the pistillate heads, grow to a diameter of an inch or more, while their slender stems increase in length to 3 or even 6 inches. The branchlets, which are at first hairy and dark-green, become orange-brown and later gray and bear conical, 2-ranked buds $\frac{1}{4}$ inch or more long.

The lower trunk, which often attains a diameter of 10 feet, is covered with thick, dark-brown bark deeply furrowed into broad rounded ridges; but upward on the trunk the thin outer bark falls in scales, exposing the inner bark. The height of the tree often exceeds 100 feet.

Distribution: From Maine westward to Iowa, southward to Florida, and again westward to Texas, the Sycamore grows on the rich borderlands of streams, rivers, and lakes. It ranges through the length and breadth of Illinois, though in the north, where favorable localities are few, it is not a common tree. In Hancock County it is said to grow, even abundantly, on rich lowlands, and it is found also on dry limestone ledges at Cedar Glenn, as well as occasionally on dry, upland slopes. In Vermilion County, on the eastern side of the State, it grows with the Beech and its associates, while in the University Woods of Champaign County it is found with such trees as maples, hickories, Buckeye, Hackberry, and Honey Locust. In the southern part of the State, Sycamore is, however, a fairly important tree; for though in the upland forests there are only about 2 trees to 100 acres, it increases in abundance on the lowlands and averages 40 trees to 100 acres in Cypress swamps, 66 trees to 100 acres on the lowlands of the main streams, and about 265 trees to 100 acres along the secondary streams.

In Thwaite's *Early Western Travels*¹, there is this note on the Sycamore: "The Sangamon bottom has a soil of amazing fertility and rears from its deep, black mould a forest of enormous sycamores; huge, overgrown, unshapely masses, their venerable limbs streaming with moss."

¹ Vol. 26, p. 320.



PLATE 63
PLATANUS OCCIDENTALIS LINNAEUS

SYCAMORE

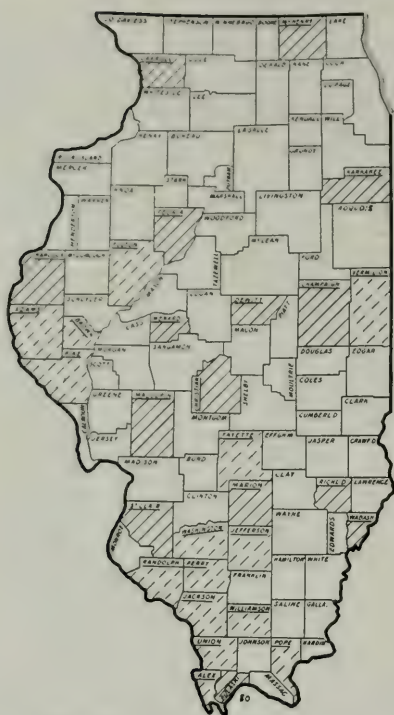


FIG. 80. Distribution of the Sycamore.

And to Andre Michaux the statement is credited that the Poplar and Sycamore were of all trees in eastern North America those that attained the greatest diameter.

Uses: The wood of the Sycamore is hard and heavy but not very strong; its worst quality, however, is the cross-grain, which makes it hard to split and renders it liable to excessive warping and twisting during the seasoning process. The heartwood is reddish and is marked with a silver grain, which gives a pleasing effect when the lumber is used for interior finishing and for furniture. Of the 1,400,000 board feet of sycamore lumber produced in Illinois during 1925, by far the greatest proportion was made into veneers and wooden ware of various kinds, such as tool handles, tobacco boxes, butcher's blocks, and the like.

MALUS HALL Apple

Family ROSACEAE

Trees of only small to very moderate size, with alternate, simple, entire, or variously lobed leaves. The flowers, borne in short, terminal racemes, have 5 green sepals, 5 white, pink, or rosy petals, about 20 stamens, and 3 to 5 pistils united into a single, inferior ovary. The fruit is a small, fleshy apple with a papery core, within which are the brown, lustrous seeds. The round, slender twigs bear small, 4-scaled buds above narrow leaf-scars. The bark is only shallowly fissured and usually is scaly.

The wide range of *Malus* in the Northern Hemisphere includes North America, southern Europe, and much of central and southern Asia. Among about 15 species, 9 occur in North America, but in Illinois only one species, *Malus ioensis* Britton, is common, although certain others, such as *M. angustifolia* Michaux, *M. lancifolia* Rehder, and *M. platycarpa* Hoopesii Rehder occur here and there.



PLATE 64

MALUS IOENSIS BRITTON

CRAB APPLE

MALUS IOENSIS BRITTON**Crab Apple**

The Crab Apple is a small, spiny tree, with a wide, open crown of stout branches. The sharply-toothed and sometimes somewhat lobed, firm leaves are dark-green and shiny above but pale, yellowish, and at least somewhat hairy beneath. The blade is from $2\frac{1}{2}$ to 4 inches long by 1 to $1\frac{1}{2}$ inches wide and stands on a slender petiole nearly an inch long. The flowers, which are $1\frac{1}{2}$ to 2 inches broad, are borne in clusters of 3 to 6 on woolly pedicels an inch or more long, and the white or rosy petals surround the stamens and the 5 styles, which are covered with long, white hairs for a third of their length. The greenish-yellow apples which cap the stout hairy pedicels are from $\frac{3}{4}$ to $1\frac{1}{2}$ inches in diameter. The reddish-brown, bright branchlets bear rather small buds with blunt points and scales hairy over their upper halves. The trunk, inclosed by a thin, red-brown, scaly bark, may become a foot or more in diameter; and the mature tree is usually between 20 and 30 feet high.

Distribution: This is a tree of the Central States, ranging, in its typical form, only from Indiana westward to Nebraska and northward to Wisconsin and Minnesota. In Illinois it occurs in many places and is frequently mistaken for the Garland Tree, *Malus coronaria* Linnaeus.

Uses: The small size of the Crab Apple renders its wood of very little commercial value. A cultivated variety, *Malus ioensis plena* Rehder, which is sold by nurserymen under the name of Bechtel Crab, is, however, one of our valuable decorative trees, highly prized for its large, double, rosy-pink blossoms.

SORBUS LINNAEUS**Mountain Ash**

Family ROSACEAE

Small, deciduous trees or shrubs, with alternate, compound, finely toothed leaves and white flowers in broad, terminal inflorescences. Each flower with 5 persistent sepals, 5 white petals, 20 stamens, and 2 to 5 pistils united at the base into a single ovary. Fruit a small, globular, orange-red, berry-like structure with sour flesh and a papery core containing shiny, brown seeds. Twigs round and slender, with conical buds standing above narrow leaf-scars. Bark usually smooth and aromatic.

Sorbus, with its many species, is widely distributed through the temperate regions of the Northern Hemisphere. Of the 4 North American species, one attains tree size.



PLATE 65

SORBUS AMERICANA MARSHALL

MOUNTAIN ASH

SORBUS AMERICANA MARSHALL

Mountain Ash

The Mountain Ash is a small tree, with a narrow, rounded crown of slender, spreading branches. The yellow-green leaves, which are 6 to 8 inches long, are made up of 6 to 8 pairs of sharply pointed finely toothed leaflets set oppositely along the midrib, which is terminated by an odd

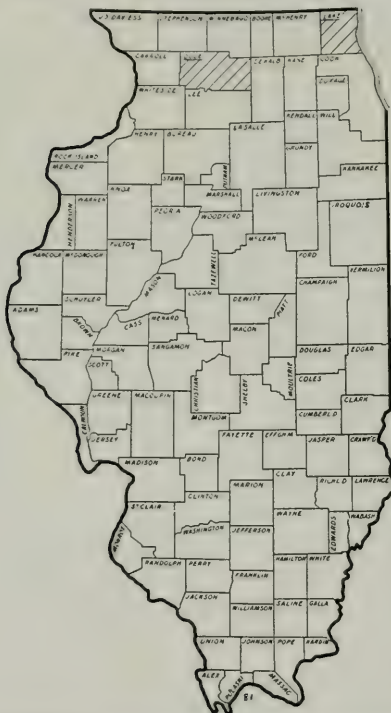


FIG. 81. Distribution of the Mountain Ash.

found near Glencoe, Wilmette, and Waukegan.

Uses: The Mountain Ash has a pale-brown, close-grained, soft wood that is of no commercial value. The chief value of the tree lies in its decorative qualities, though the acid fruits are employed in the manufacture of certain medicinal preparations.

leaflet. The flat inflorescence is 3 or 4 inches wide and is made up of many small flowers, which stand on short, stout stalks. The bright, orange-red, fleshy fruit, which is about $\frac{1}{4}$ inch in diameter, contains a brown seed about $\frac{1}{8}$ inch long. The trunk, which is covered by thin, smooth, gray bark, is usually less than a foot in diameter; and the tree attains an ordinary height of a little over 20 feet.

Distribution: The Mountain Ash ranges from Newfoundland to Manitoba and southward to North Carolina and Tennessee. In Illinois it is a very rare tree and is known to us by only three records: W. G. Waterman reports it as one of the trees inhabiting the bogs of Lake County; a specimen from Oregon, Ogle County, bears the notation that the tree is "native"; and Pepon says the tree is rare in the woods along Lake Michigan, being

AMELANCHIER MEDICUS

Service Berry

Family ROSACEAE

Small, deciduous trees or shrubs, with alternate, broad-bladed, simple leaves and small white flowers borne in erect, terminal racemes. Each flower with 5 persistent sepals, 5 petals, 20 stamens, and 5 pistils united

into a single ovary. Fruit a globular, blue to black, fleshy "berry" containing 5 or 10 dark-brown seeds. Twigs slender, zig-zag, with 5-angled, pale pith and long buds covered with twisted scales. Bark usually scaly.

Though there are many species of *Amelanchier* in North America, there is but one in southern Europe, northern Africa, and southwestern Asia; and another in eastern Asia. The tree forms, 3 in number, are all American, and one of these grows in Illinois.

AMELANCHIER CANADENSIS MEDICUS

Shad Bush

Service Berry

The Shad Bush forms a tree of only very moderate size. It has a narrow head of small, spreading branches. The sharply pointed, sharply toothed, yellow-green leaves, which are 2 to 4 inches long by 1 to 2 inches wide, paler and usually a little hairy beneath, stand on slender petioles nearly 2 inches long. The small, white flowers are grouped in drooping racemes, and resemble those of cherries at a distance. The purple fruits, each about $\frac{1}{4}$ inch in diameter, are dry and insipid. The slender, red-brown branchlets bear green buds $\frac{1}{2}$ inch or more long. The trunk, which is not often more than a foot in diameter, is covered by thin, gray bark shallowly fissured into scaly ridges.

Distribution: The Shad Bush ranges from Maine to Nebraska and southward to Florida and Oklahoma. It is found in many parts of Illinois.

Uses: The heavy, hard wood of the Shad Bush, so called because its blossoming was considered in New England a sign of the proper time to fish for shad, is of little commercial value, although it has been used for tool handles, fishing rods, bows, lances, and other articles generally classed as turnery.



FIG. 82. Distribution of the Shad Bush.



PLATE 66

AMELANCHIER CANADENSIS MEDICUS

SERVICE BERRY

CRATAEGUS LINNAEUS

The Hawthorns

Family ROSACEAE

The Hawthorns, the smallest of our trees, are generally 15 feet but seldom more than 30 feet high. They are, in the main, spiny, shrubby-looking, deciduous trees, with short trunks, stout, coarse, ascending, or spreading branches, and broad, open heads. The leaves are alternate, simple, generally toothed, often more or less lobed, and distinctly petiolate. The flowers, which occur in small or large groups on the ends of short, lateral, leafy branches, have, in common with most members of the rose family, 5 persistent, green sepals, 5 white, or rarely rosy, deciduous petals, stamens, in sets of 5, from 5 to 25 in number, and in the bottom of the calyx-tube 1 ovary composed of 1 to 5 basally united pistils. The fruit is a globular, variously colored, dry and mealy-fleshed "haw" containing from 1 to 5 more or less united, hard, and bony-shelled nutlets, within which there are solitary, brown seeds. The twigs are slender to moderate, round, and contain rather small pith. The buds are small and globular and stand above narrow, lunar leaf-scars. The bark is usually dark and scaly.

Although a few species of *Crataegus* occur in Europe, Asia, and western North America, by far the greater number are in eastern North America. The wood of these trees is hard and tough and is used for small articles such as mallets, tool handles, fishing rods, wooden type, and the like. In North America, no less than 153 species have been distinguished; but the proper identification is a task for the expert. The following key to certain Illinois species, some of which are known only from Illinois, will prove helpful; but in every case the technical manuals should be consulted for detailed descriptions, and the opinions of experts should be obtained for every doubtful instance.

The three plates shown here exemplify the three types of *Crataegus* which occur in Illinois, arranged according to the shape of their leaves, as in the key. *C. Phaenopyrum* (Plate 67) has triangular leaves; *C. Crusgalli* (Plate 68) has leaves which are broadest above the middle, with their bases sloping onto the petioles; and *C. mollis* has leaves which are broadest at the base.

KEY TO THE ILLINOIS HAWTHORNS.

Typical leaves distinctly triangular, their wide, flat bases extending nearly at right angles to the petioles (Plate 67).....*C. Phaenopyrum* Med.

Leaves variously shaped, but their bases distinctly sloping onto the petioles.

Leaves broadest at or above the middle (Plate 68).

Petioles short.

Small veins thin, buried in the leaf, inconspicuous.

Spines 3 to 4 inches long; haws dull red.....*C. Crus-galli* L.

Spines up to $2\frac{1}{2}$ inches long; haws scarlet...*C. peoriensis* Sarg.

Small veins prominent, at least below.

Haws longer than wide.....*C. punctata* Jacq.

Haws globose.....*C. pratensis* Sarg.

Petioles elongated, generally slender.

Spines long, $1\frac{1}{2}$ to 4 inches.

Haws small, $\frac{1}{4}$ to $\frac{1}{3}$ inch long.....*C. macracantha* Koehne

Haws larger, about $\frac{1}{2}$ inch long.....*C. illinoensis* Ashe

Spines short, $\frac{3}{4}$ to $1\frac{1}{2}$ inches long.

Leaves large, generally more than 2 inches long.

Haws juicy and sweet.....*C. tomentosa* L.

Haws dry.....*C. nitida* Sarg.

Leaves smaller, generally 1 to 2 inches long.

Haws very small, $\frac{1}{8}$ to $\frac{1}{4}$ inch long.....*C. viridis* L.

Haws larger, about $\frac{1}{2}$ inch long...*C. rotundifolia* Moench.

Leaves broadest at the base (Plate 69).

Leaves large, generally $2\frac{1}{2}$ to 4 inches long.

Haws $\frac{3}{4}$ to 1 inch long, dry and mealy.....*C. mollis* Scheele

Haws about $\frac{1}{2}$ inch long, juicy.....*C. Hillii* Sarg.

Leaves smaller, generally not over 2 inches long.

Haws juicy*C. apiomorpha* Sarg.

Haws dry and mealy.

Haws on long, thin, bright-red pedicels...*C. pruinosa* K. Koch

Haws on short, stout pedicels.....*C. lucorum* Sarg.



PLATE 67

CRATAEGUS PHAENOPYRUM MEDICUS

WASHINGTON THORN



PLATE 68

CRATAEGUS CRUS-GALLI LINNAEUS

COCK-SPUR THORN



PLATE 69

CRATAEGUS MOLLIS SCHEELÉ

RED HAW

PRUNUS BENTHAM AND HOOKER

Plums and Cherries

Family ROSACEAE

Small, deciduous trees, usually between 20 and 30 feet high, with alternate, broad-bladed, simple leaves and white flowers in terminal or axillary groups. Each flower with 5 sepals, 5 petals, 15 to 30 stamens, and a single ovary in the bottom of the calyx tube. Fruit a one-seeded drupe with thick, pulpy, or dry flesh covering the hard, bony pit. Slender branchlets with small, globular, or conical buds above very small, raised leaf-scars.

With many more than a hundred species, *Prunus*, which includes both the plums and the cherries, is to be found throughout most of the temperate parts of the Northern Hemisphere, and it ranges southward into tropical America and southern Asia. Of about 22 American tree-sized species, 5 are fairly common in Illinois.

KEY TO THE ILLINOIS PLUMS AND CHERRIES

Terminal buds falling off, fruit a plum.

Leaves sharply toothed, plums bright-red.....*P. americana* p. 212

Leaves bluntly toothed, plums deep-red or yellow.....*P. hortulana* p. 213

Terminal buds persistent, fruit a cherry.

Flowers and fruit in stalkless clusters from buds in the axils of leaf-

scars*P. pennsylvanica* p. 216

Flowers and fruit on the ends of short, leafy branches.

Flowers $\frac{1}{4}$ inch wide, cherries "puckery".....*P. virginiana* p. 217

Flowers larger, cherries juicy and pleasant.....*P. serotina* p. 220



PLATE 70

PRUNUS AMERICANA MARSHALL

WILD PLUM

PRUNUS HORTULANA BAILEY

Wild Goose Plum

The Wild Goose Plum is a small tree, with spreading branches and a broad crown. The thin, dark-green, shiny leaves, 4 to 6 inches long and an inch or more wide, are finely toothed on their margins and stand on slender, orange petioles an inch or more long. The white flowers, the petals of which are often orange-tinted at their bases, stand in small clusters above year-old leaf-scars. The deep-red or yellow plums, rarely an inch in diameter, have rather hard flesh and rough, pitted stones. The dark, red-brown branchlets, which are seldom spine-like, bear tiny, blunt, brown buds. The slender, leaning trunk, covered by dark-brown, thinly plated bark, is not often more than half a foot in diameter; and the tree may attain a height of 30 feet.

Distribution: This plum, native along stream banks in the Central States and often cultivated, occurs through most of southern and western Illinois and is undoubtedly more prevalent than our records suggest. Records from more northern stations, however, we regard as cases of incorrect identification.

Uses: In common with most plums, the wood of this tree is close-grained and durable, though little used commercially. The horticultural varieties are, however, not only numerous but valuable.



FIG. 84. Distribution of the Wild Goose Plum.

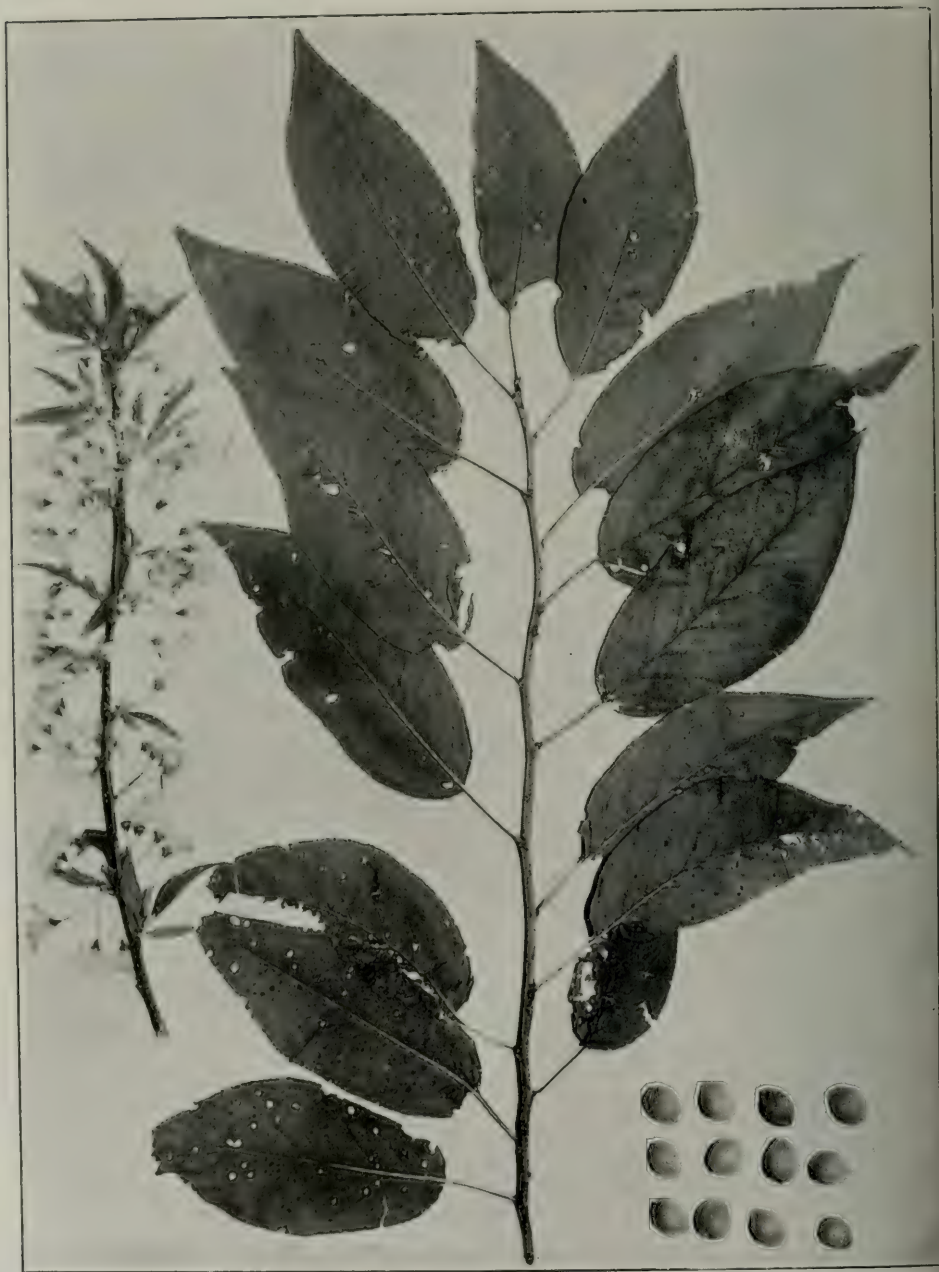


PLATE 71

PRUNUS HORTULANA BAILEY

WILD GOOSE PLUM



PLATE 72

PRUNUS PENNSYLVANICA LINNAEUS WILD RED CHERRY

PRUNUS PENNSYLVANICA LINNAEUS

Wild Red Cherry.

Bird Cherry

The Wild Red Cherry is a moderately small tree, with a narrow crown of slender, horizontal branches. The bright, shiny, green leaves, 3 to 5 inches long by about an inch wide, are finely toothed along their margins, very sharply pointed, and stand on slender petioles generally

less than an inch long. The small clusters of flowers, whose petals bear a band of orange, stand above year-old leaf-scars. The cherries, seldom more than $\frac{1}{4}$ inch in diameter, are light-red and have thin, sour flesh surrounding the hard pit. The bright-red branchlets, often spiny, bear tiny, bright-brown buds. The trunk, covered by red-brown bark which separates into broad, horizontal, papery scales, becomes 18 to 20 inches in diameter; and the tree may grow to a height of 30 feet or more.

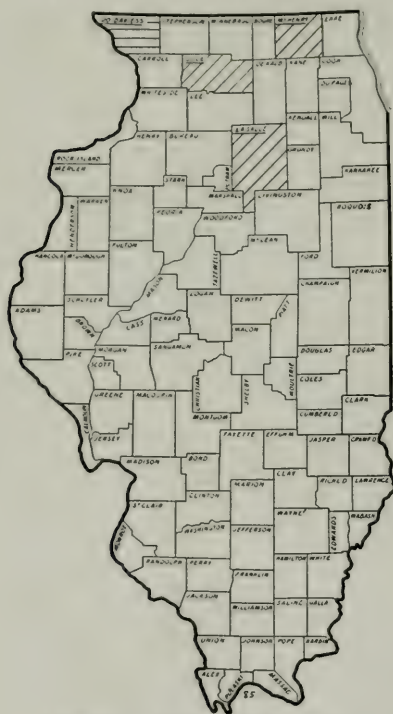


FIG. 85. Distribution of the Wild Red Cherry.

tions from which our map is marked seem to indicate.

Uses: As the tree is not abundant, it is of little economic importance. The cherries are, however, commonly used in households and they are also employed as an ingredient of cough medicines.

Distribution: The Bird Cherry grows generally in all the forested regions of North America from Hudson's Bay southward into the mountains of the states bordering the Ohio River. In Illinois, however, it is limited in its distribution to an area comprising about the northern third of the State, and through this region it is undoubtedly more prevalent than the collections

PRUNUS VIRGINIANA LINNAEUS

Choke Cherry

The Choke Cherry is a decidedly small tree, with a small crown of small branches. The sharply toothed, short-pointed, dark-green leaves, 2 to 4 inches long by 1 to 2 inches wide, stand on slender petioles nearly an inch long, which bear 2 distinct glands near the base of the blade. The white flowers, nearly an inch in diameter, are borne, each on short stalks, in crowded racemes 3 to 6 inches long. The shiny, dark-red to black cherries, the flesh of which is dark, juicy, and "puckery," are usually more than $\frac{1}{4}$ inch in diameter and contain a hard pit. The slender, red-brown twigs bear large, brown buds. The trunk, inclosed by ill-scented, warty and scaly, red-brown bark, is not often more than 6 inches in diameter; and the tree is usually 20 or 25 feet high.

Distribution: Shrubby in its northern range, tree-like in the south, the Choke Cherry ranges almost transcontinentally from Hudson's Bay to the Gulf of Mexico. Though more common in the counties of northern Illinois, it is found southward to Madison County in the west and Wabash County in the east.

Uses: The wood of the Choke Cherry, though of high quality in some respects, is weak and has little commercial value. The cherries, however, if not gathered too soon, may be made into delightfully flavored jelly.



FIG. 86. Distribution of the Choke Cherry.



PLATE 73

PRUNUS VIRGINIANA LINNAEUS

CHOKE CHERRY



PLATE 74

PRUNUS SEROTINA EHRHART

WILD BLACK CHERRY

PRUNUS SEROTINA EHRLHART

Wild Black Cherry

Rum Cherry

The Wild Black Cherry is often a moderate-sized to large tree and has a narrow head of small, horizontal branches. The leathery, dark-green leaves, 2 to 6 inches long by somewhat more than an inch wide and sharply toothed along the margins, stand on slender petioles half an inch or more long. The many-flowered, white racemes become 4 to 6 inches long, and the cherries, almost black when they are ripe and nearly $\frac{1}{2}$ inch in diameter, contain hard pits. The dark-brown to bright-red branchlets bear chestnut-brown buds $\frac{1}{2}$ inch or more in length. The trunk, clothed in dark, red-brown, plated bark, may attain a diameter in excess of 2 feet; and the tree may grow to a height of 80 feet or more.

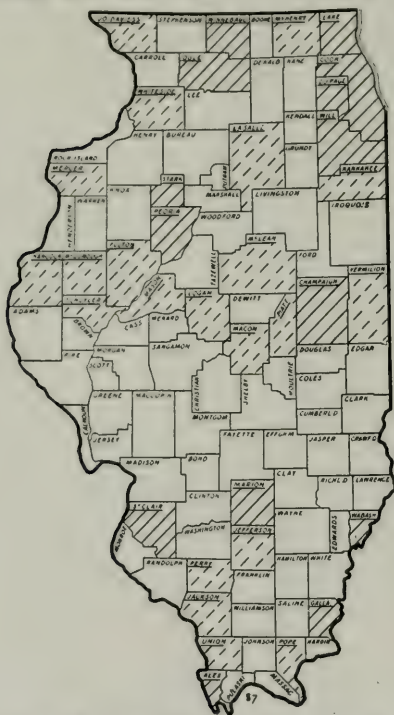


FIG. 87. Distribution of the Wild Black Cherry.

ages 1 per cent of the stand; and even on the bottomlands of main streams it still occurs in appreciable numbers. In Jo Daviess County, Black Cherry attains an average height of 50 feet; farther south, in Hancock County, it attains a height of 72 feet; and in McLean County the maximum height among the measured trees was 82 feet.

Uses: The close- and straight-grained, light-brown wood of the Wild Black Cherry possesses many desirable technical qualities. It is light, strong, and rather hard; and, because of the satiny finish it takes, it is used quite extensively in the making of fine cabinet articles as well as for the interior finish of houses. It is the one Illinois cherry with a real commercial value.

Distribution: The Wild Black Cherry, in its favorite situation along the margins of forests, ranges throughout much of the eastern half of North America, from Hudson's Bay in the north to Alabama in the south. It is by far the most common cherry in Illinois and ranges throughout the State. Among the hardwoods of the upland forests, it constitutes between 1 and 2 per cent of the stand; along the secondary streams, it averages

From the bark, hydrocyanic acid is extracted, and this is used in the preparation of sedative and tonic medicines. Formerly, the ripe fruits also supplied flavors for alcoholic beverages.

CERCIS LINNAEUS**Judas Tree**

Family LEGUMINOSAE

Small to moderate, deciduous trees, with alternate, entire, simple, broad-bladed, 5- to 7-nerved leaves and somewhat pea-like, colored flowers clustered above the past-year's leaf-scars. Fruit an elongated, flattened, rather woody, purplish pod with bright, reddish-brown seeds. The slender, zig-zag twigs have pale to pinkish pith, no terminal bud, oval, scaly, and often stalked lateral buds, and raised and rather distinctly triangular leaf-scars fringed at the top and marked with 3 bundle-traces. The bark is usually scaly.

This genus, of which there are 8 known species, occurs rather widely through the temperate and warmer regions of the Northern Hemisphere. Its original home, in ancient geological times, is supposed to have been in Central Asia, from which a large number of species are thought, from fossil records, to have migrated to many parts of the world, and some of these are considered to be the ancient but direct ancestors of our modern species, which are themselves so old that their history extends back to the Ice Age. Our Northern American species are now only 3 in number, 2 of them tree-like; and only the well known Redbud occurs in Illinois.



FIG. 87a. Bark of the Red Bud.
*Photo from the Field Museum
of Natural History.*

CERCIS CANADENSIS LINNAEUS

Redbud

Judas Tree

The Redbud, a tree of only very moderate height, usually branches 10 feet or so upward into a flat, wide crown of stout limbs. The very broad, rounded, and pointed, heart-shaped leaves, 3 to 5 inches in diameter, stand on petioles 2 to 5 inches long. The brilliant, rosy-red flowers, each about $\frac{1}{2}$ inch long, occur, 4 to 8 together, in stalkless bundles above year-old leaf-scars. The pinkish or rosy pod, usually 2 to 3 inches long, contains numerous brown seeds about $\frac{1}{4}$ inch long. The dull or shiny, brown branchlets bear small, scaly buds above the triangular, fringed leaf-scars. The trunk, covered by red-brown, deeply fissured, scaly bark, seldom attains a diameter of more than a foot, while the tree itself does not often exceed 40 feet in height.



Distribution: From Pennsylvania to Florida the Redbud ranges westward, in rich woodlands and along streams, to Nebraska and Texas. It grows practically throughout Illinois and is one of the most striking trees in the understory of our woodlands when its brilliant flowers appear in the spring.

Uses: The rich, brown, red-tinted wood of the Redbud, though hard and close-grained, is not strong and has practically no commercial use. As an ornamental tree, however, the Redbud is used extensively and may be purchased directly from nurserymen, most of whom propagate it artificially in their tree and shrub nurseries.

GYMNOCLADUS LAMARK

Coffee Bean

Family LEGUMINOSAE

Rather large, deciduous trees, with large, alternate, doubly compound leaves and greenish, long-stalked flowers, the staminate and pistillate flowers separate and on separate trees. Fruit an elongated, tough,



PLATE 75

CERCIS CANADENSIS LINNAEUS

REDBUD

woody pod containing several seeds. The stout, rounded twigs, with large, round, salmon pith, bear 2 buds set one above another, each nearly buried in a silky pit, above each large, rather heart-shaped leaf-scar.

There are but 2 species, one in eastern North America and one in China. In this respect, it is like the Tulip Tree and the Sassafras, for all three appear to be isolated survivors of ancient stocks, though little is known of their early history.

GYMNOCLADUS DIOICUS K. KOCH

Kentucky Coffee Tree

Mahogany

The Kentucky Coffee Tree is large and stately, with 3 or 4 upright main stems which form a narrow, round-topped crown. The much-



FIG. 89. Bark of the Kentucky Coffee Tree. Photo from the Field Museum of Natural History.

divided leaves, usually between 2 and 3 feet long by $1\frac{1}{2}$ to 2 feet wide, are made up of numerous dark-green leaflets, 2 to $2\frac{1}{2}$ inches long by an inch wide, set along the branches of the petiole. The greenish-white flowers stand in terminal racemes, the staminate racemes 3 or 4 inches long, the pistillate racemes nearly a foot long. The dark-red pods, 6 to 10 inches long by 1 to 2 inches wide, hang from stout stalks 1 or 2 inches long, and remain closed through the winter. The seeds, which are about $\frac{3}{4}$ inch long, are separated in the pod by dark, sweet pulp. The trunk, often 2 feet or more in diameter, is covered by red-tinted dark-gray bark, which is deeply fissured and scaly. The tree is generally more than 70 feet high.

Distribution: Though not anywhere a common tree, the Kentucky Coffee Tree ranges, particularly on rich bottomlands, from New York westward to Nebraska and southward only to Kentucky and Tennessee. Formerly, at least, it ranged throughout the lowlands of Illinois, but now



PLATE 76

GYMNOCLADUS DIOICUS K. KOCH KENTUCKY COFFEE TREE



PLATE 77

GLEDITSIA TRIACANTHOS LINNAEUS

HONEY LOCUST

GLEDITSIA TRIACANTHOS LINNAEUS

Honey Locust

The Honey Locust is a large and graceful tree, with a broad, open head of slender and somewhat drooping branches. The large leaves, often 8 inches long, are made up of numerous dark-green and shiny leaflets, each an inch or more in length and $\frac{1}{2}$ inch in width. The greenish-



FIG. 91. Trunk of the Honey Locust. The greatly branched spines are a sure means of identification. Photo from the Field Museum of Natural History.

yellow flowers grow in racemes from the axils of year-old scars, the staminate racemes often clustered and crowded with flowers, the pistillate racemes usually alone, few-flowered, and graceful. The dark-brown pods, 12 to 18 inches long, hang in groups of 2 or 3, each on a stout stalk an inch or more in length, and contain a number of oval seeds. The lustrous, greenish-red to brown branchlets bear small buds and bright, red, 3-forked thorns above the leaf-scars. The trunk, the bark of which is divided by deep fissures into long, narrow, scaly ridges, becomes 2 or 3 feet thick, and the tree grows to a height of 70 to 100 feet.

Distribution: From Pennsylvania westward to South Dakota and southward to Florida and Texas, the Honey Locust thrives on moist and fertile soils. It ranges throughout Illinois, growing not only along streams and on the bottomlands, where

the largest and best trees are always found, but also on the uplands. Infrequently, it forms pure stands, which cover small areas, but it is usually a solitary tree. It grows promiscuously, though nowhere abundantly, with the White, Black, Pin, and Burr oaks, Elm, Bass Wood, Black Walnut, Wild Black Cherry, Shagbark, Pecan, and numerous other trees. Robert Ridgway, who measured many of the large trees of the Wabash Valley before they were cut, gives the measurements of a Honey Locust standing in 1871 as 120 feet in height, with 50 feet of clear trunk and a circumference of 17 feet.

Uses: The bright, reddish-brown, coarse-grained wood of the Honey Locust is hard as well as strong, and it is very durable in contact with the soil. As a consequence, it is used quite extensively for fence posts and rails and for railroad ties. It also furnishes a fair grade of charcoal. Although the radial surface of its lumber shows a pleasing silver grain, the design is not sufficiently pronounced to give the lumber exceptional value as a finishing material.



FIG. 92. Distribution of the Honey Locust.

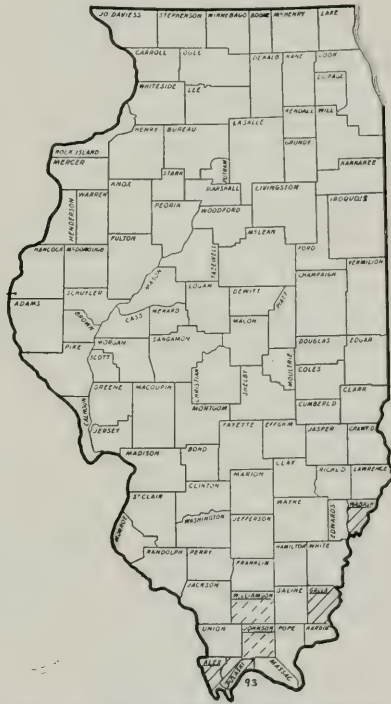


FIG. 93. Distribution of the Water Locust.

GLEDITSIA AQUATICA MARSHALL

Water Locust

The Water Locust is a tree of rather moderate size, with a wide, irregular crown formed by stout, spreading limbs which arise very close to the ground. The rather large leaves, 5 to 8 inches long, are made up of a number of dull, yellow-green leaflets about 1 inch long by $\frac{1}{2}$ inch



PLATE 78

GLEDITSIA AQUATICA MARSHALL

WATER LOCUST

wide, set in pairs along the simple or branched petiole. The greenish flowers stand in slender racemes 3 to 4 inches long, each flower on a short, purple stalk. The bright-brown, oval pods, 1 to 2 inches long by an inch wide, hang from long stalks and contain 2 or 3 nearly round, flat, orange-brown seeds. The orange-tinted, brown branchlets bear unbranched, sharp, rigid spines 3 to 5 inches long. The short trunk, which is clothed in smooth, dull-gray, shallowly fissured, and plated bark, may become 2 feet thick, and the tree rises to a height of 60 feet or more.

Distribution: The Water Locust is distinctly a southern tree and is, moreover, an inhabitant of swampy and overflowed lands. It ranges from South Carolina to Florida, westward through the Gulf Coast region into Texas, and northward again along the Mississippi into southern Illinois, where it grows as an occasional tree on the swampy bottomlands of the Mississippi, the Cache, the Ohio, and the Wabash rivers. Along the Cache River, it grows rapidly attaining a height of 80 feet and a diameter of 18 inches in 60 years. Its principal associates are the Honey Locust, Tupelo Gum, Elm, Cypress, and ashes.

Uses: The rich, bright, red-tinted, brown wood of the Water Locust is heavy, strong, and hard, though coarse-grained. When freshly cut, it has an unpleasant odor. In Pulaski County, the Water Locust is cut and sawed into lumber, which is used both in cabinet work and as a finishing wood for the interior of buildings.

ROBINIA LINNAEUS

Locust

Family LEGUMINOSAE

Deciduous trees and shrubs, with alternate, compound leaves and brightly colored, pea-like flowers in stalked racemes arising from the axils of the new leaves. Fruit a long, flat, short-stemmed, membranous pod containing many seeds. Twigs zig-zag and somewhat angled, with round, brown pith, small buds covered by persistent membranes, broadly triangular leaf-scars, and spiny, persistent stipules.

Robinia, with its 8 species, is confined to the North American Continent. Although the fossil forms that have been found can be distinguished only with the greatest difficulty from those of similar trees, such as the Honey Locust, it is certain that during past ages Robinia was not only much more widely distributed through the world but was also represented by a much greater variety of forms. Our common Black Locust, one of 3 tree forms now present in the United States, is known to have lived, during the interglacial periods, in the Province of Ontario and, at a still later time and for many succeeding centuries, in France.

ROBINIA PSEUDOACACIA LINNAEUS

Black Locust

Acacia

Yellow Locust

The Black Locust is a tree of only moderate size, with a high, narrow head of small, uptilted branches. The large leaves, usually about a foot long, are composed of an odd number of oval leaflets, ranging from 7 to 19, set oppositely in pairs along the slender, somewhat hairy, and un-

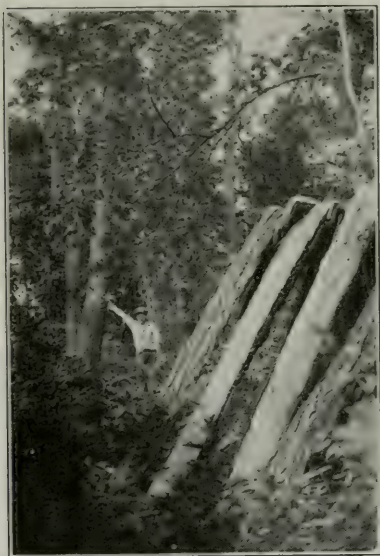


FIG. 94. Fifty-year old stand of Black Locust on sand near Havana. One tree yielded 40 split and 4 round posts.

branched petiole, which bears a single leaflet at its tip. The fragrant, nectar-bearing flowers, with their pure-white petals and red-blotched, green sepals, hang in beautiful racemes, 4 or 5 inches long, from the axils of the leaves. The bright, reddish-brown pods, which are 3 or 4 inches long and half an inch wide, contain from 4 to 8 orange-brown, darkly marked seeds nearly $\frac{1}{4}$ inch long. The light reddish-brown, many-angled to round branchlets have their leaf-scars and buds covered by a persistent membrane, and the stipules persist as sharply pointed spines. The trunk, which is inclosed by deeply furrowed, scaly, reddish-brown bark, grows to a diameter of 3 feet or more; and the tree, though sometimes very tall, is usually less than 80 feet high.

Distribution: Though widely naturalized and cultivated in a considerable variety of selected forms, the Black Locust ranges naturally from Pennsylvania to Virginia and westward to the Mississippi River. In Illinois, though far from abundant in any place, it ranges practically throughout the State, selecting light and fairly open situations. It is commonly associated with such trees as Black Walnut, Wild Black Cherry, ashes, White and Burr oaks, and Tulip Trees. Some of the best of the older stands occur in Whiteside County, where the most common associate is Burr Oak.

Uses: The heavy, close-grained wood of the Black Locust is exceedingly hard and strong. From it are manufactured the "tree-nails" used for pinning together the timbers of ships. Its durability also makes



PLATE 79

ROBINIA PSEUDOACACIA LINNAEUS

BLACK LOCUST

of the Maples, begun at a time when the polar regions were warm and forest-covered, has persisted through the ages. In our modern forests, they are among the climax trees, and several of our best known species were already in existence when the great ice sheets of the Glacial Period over-ran the northern world.

Today, the North American maples that attain tree size are 13 in number, and 5 of these, with several of their varieties, are natives of Illinois.

KEY TO THE ILLINOIS MAPLES

Leaves compound **A. Negundo** p. 246
 Leaves simple but palmately lobed.

Leaves generally 3-lobed.

Flowers and seeds in lateral fascicles. . **A. rubrum Drummondii** p. 244

Flowers and seeds terminal, or from subterminal buds.

Leaves velvety-hairy beneath..... **A. nigrum** p. 238

Leaves pale but not hairy beneath..... **A. saccharum** p. 235

Leaves generally 5-lobed.

Flowers almost stalkless; leaves deeply cut, silvery-white beneath; petioles 4 or 5 inches long..... **A. saccharinum** p. 240

Flowers long-stalked; leaves moderately lobed, hairy beneath; petioles 2 to 4 inches long..... **A. rubrum** p. 243

ACER SACCHARUM MARSHALL

Sugar Maple

Hard Maple

The Sugar Maple is a very tall tree, with a high, clear bole crowned with a wide, dome-like head of large branches. The 3-lobed, or less often 5-lobed, dark-green, leathery leaves, which are usually 4 to 5 inches long and pale and smooth beneath, stand on slender petioles $1\frac{1}{2}$ to 3 inches long. The greenish-yellow flowers, with 5 sepals but no petals, occur in terminal or nearly terminal fascicles and are borne on slender stalks that vary in length from $\frac{3}{4}$ to 3 inches. The bright, red-brown seeds, about $\frac{1}{4}$ inch long, have broad, thin wings from $\frac{1}{2}$ to 1 inch long. The slender, shiny, reddish-brown twigs bear small, pointed, purplish buds. The trunk, with its covering of deeply fissured, gray-brown, scaly bark, grows to a diameter of 3 feet or more, and the tree often attains a height of 100 feet, the bole rising 50 feet or more to the first branches.

Distribution: The range of the Sugar Maple extends from Nova Scotia westward across Canada beyond Winnipeg and southward into Georgia and Mississippi. In Illinois, it grows particularly in the upland hardwood forests throughout the State, selecting moderately deep, well-drained, fertile loam soils. "Sugar tree land," however, is usually rated as poorer than "black walnut land." The common associates of the Sugar Maple are Bass Wood, Black Walnut, White, Black, and Red

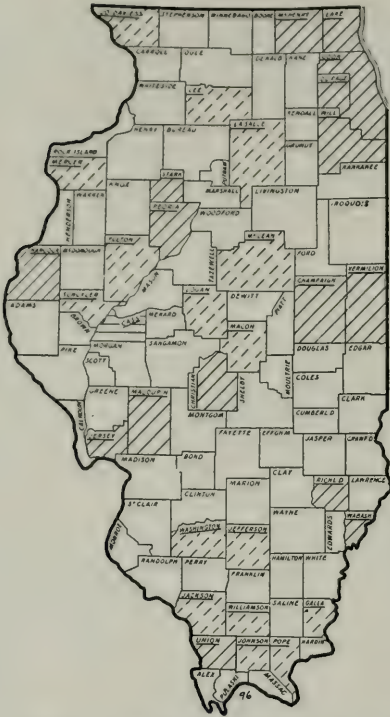


FIG. 96. Distribution of the Sugar Maple.

oaks, hickories, ashes, Elm, Wild Black Cherry, Mulberry, Hackberry, Kentucky Coffee Tree, Honey Locust, and Redbud. On the high moraines of Vermilion County, however, it is found especially with the White, Red, Black, and Burr oaks, Beech, Sycamore, Sassafras, and several of the trees previously named.

Besides the typical Sugar Maple, two varieties are known to occur in Illinois. The variety *Rugelii* Rehder, in which the leaves have 3 long, pointed, smooth-margined lobes, has been found in Richland County by Robert Ridgway, in Wabash and Johnson counties by Jacob Schneck, in Jackson County by L. T. Cranwill, and in White County. The variety *Schneckii* Rehder, which is distinguished from the typical Sugar Maple by the presence of hairs on the veins beneath the leaf, has been found in nine southern counties, Richland, Ed-

wards, Wabash, Gallatin, Hardin, Pope, Johnson, Pulaski, and Alexander. Neither of these varieties is, however, abundant; and the distinctions between them and typical trees will not be made by the usual observer.

Uses: The hard, fine-grained wood of the Sugar Maple is heavy and takes a beautiful polish, to the appearance of which a slight silver grain on the radial surface lends a distinctive touch. It is among the most useful and most valuable of our Illinois hardwoods. The uses to which it is put make a long list and include furniture, flooring, boxes, crates, shoe parts (such as lasts, shanks, and pegs), farming implements, musical instruments, wooden ware of many kinds, and laundry appliances, as well as wagon axles, tool handles, bobbins for cotton mills, trunks, toys, cutting blocks, slack cooperage, and veneers.

Two very valuable types of lumber are derived from the Sugar Maple. Certain trees, in which the grain has become twisted and contorted during growth, furnish the ornamental "curly" maple so extensively used in cabinets; while other trees, within whose trunks the adven-



PLATE 80

ACER SACCHARUM MARSHALL

SUGAR MAPLE

titious buds have been buried, furnish the highly decorative "birdseye" maple so greatly prized for small panels in beds, cabinets, and walls.

Sugar Maple logs are easily split, and this, together with their hardness, makes them admirably suited for fuel purposes. The ashes, which were formerly much used in the manufacture of soft soap, contain a considerable amount of phosphate and are valuable as lawn and orchard fertilizers. The wood ranks with beech for distillation purposes.

The maple sugar and the maple syrup of commerce are also obtained from this tree.

ACER NIGRUM MICHAUX

Black Maple

The Black Maple is a tree of somewhat more than medium height, with a shallow, flat-topped crown of stout, spreading branches. The thick, firm, dull-green leaves, usually 3-lobed, but occasionally 5-lobed, and yellow-green and velvety-hairy beneath, are between 5 and 6 inches long and

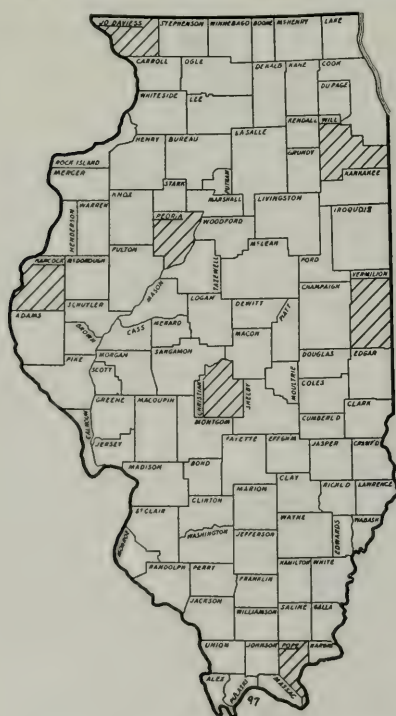


FIG. 97. Distribution of the Black Maple.

hang on stout, hairy petioles 3 to 5 inches long, the enlarged bases of which nearly cover the buds. The yellow flowers, which have 5 sepals but no petals, hang from slender, hairy stalks, $2\frac{1}{2}$ to 3 inches long, arranged in terminal fascicles. The keys, the wings of which usually spread widely, are between $\frac{1}{2}$ and 1 inch long and carry bright, red-brown seeds about $\frac{1}{4}$ inch long. The orange-brown branchlets bear very hairy, pointed, dark red-brown buds set deep in the narrow leaf-scars. The thick and deeply furrowed bark covers a trunk which may attain a diameter of $2\frac{1}{2}$ to 3 feet, while the tree may rise to a height of 70 or 80 feet.

Distribution: Though always a rare and localized tree, the Black Maple ranges from Montreal westward to South Dakota and southward into New York, West Virginia, Kentucky and Missouri. In Illinois, as



PLATE 81

ACER NIGRUM MICHAUX

BLACK MAPLE

may be judged from the map, it is a widely distributed but not common tree. Its occurrence in the State is known chiefly through the collections of Virginius H. and Agnes Chase, Frank C. Gates, and C. J. Telford, though specimens obtained by other collectors have been seen.

Uses: Though the Black Maple is not sufficiently abundant to be an important timber tree in Illinois, its wood, which is not easily distinguishable from that of the Sugar Maple, can be used for practically all the purposes for which hard maple is suitable.

ACER SACCHARINUM LINNAEUS

Silver Maple

Soft Maple

The Soft Maple, or Silver Maple, is a tree considerably over medium height, with a divided bole consisting of 3 or 4 stout, upright limbs and with a broad head of drooping lateral branches that turn upward toward the ends. The thin, bright, pale-green leaves, which are 6 to 7 inches long

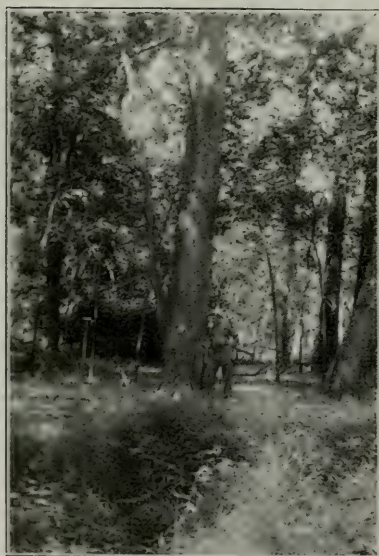


FIG. 98. Silver Maple on the Mississippi bottoms, near Atwood Ridge, in Union County.

and distinctly white beneath, are divided very deeply into 5 distinctly toothed lobes and hang on slender, drooping, bright-red petioles 4 or 5 inches long. The greenish-yellow flowers, which lack petals, hang on short stalks from the axils of the past year's leaves. The large keys, which are usually between $1\frac{1}{2}$ and 3 inches long, have wings nearly $\frac{3}{4}$ inch wide and carry pale-brown seeds $\frac{1}{2}$ inch long. The trunk, covered by red-brown, furrowed, scaly bark, may become 3 feet or more in thickness, and the tree may grow to a height of 80 feet or more.

Distribution: From New Brunswick westward into South Dakota and southward to Florida and Louisiana, the Silver Maple is found along the banks of streams and on low, often submerged, swampy lands. In Illinois, its range includes the entire State and it grows in a considerable variety of situations, with an equally varied assortment of tree species in association with it. On the Mississippi bottomlands of Carroll County, it constitutes 32 per cent of the merchantable



PLATE 82

ACER SACCHARINUM LINNAEUS

SILVER MAPLE

The Silver Maple grows rapidly, in this respect ranking next to Sycamore among the Illinois trees. In a 40-year-old stand examined by our forest survey party, the Silver Maple had grown at an average rate of 53 cubic feet per year per acre—a rate exceeded only by the Cottonwoods, which had averaged 96.7 cubic feet, and by the Sycamores, which had averaged nearly 63 cubic feet. In Wabash County, near Mt. Carmel, several 100-year-old trees had attained a height of 107 feet, and their trunk diameters averaged 33 inches. Such trees will each yield nearly 1400 board feet of lumber. On the Mississippi bottom-land at Ware, Union County, a tree 76 years old had attained a height of over 100 feet and a trunk diameter of 29½ inches. Robert Ridgway reports that a tree on his estate near Olney added 2 feet 4 inches to its circumference in 9 growing seasons.

Uses: Though inferior to either Red Maple or Sugar Maple, the pale-brown wood of the Silver Maple is used quite extensively for a variety of purposes. It is close-grained and easily worked, though rather brittle. Besides being sawn into rough lumber and flooring, it is manufactured into furniture, barrel heads and staves, and veneers. When treated against decay, it is serviceable for railroad ties, and a considerable amount is used for piles.

Because of its susceptibility to attack by the cottony maple scale, it does not make a satisfactory shade tree, though a variety with finely divided leaves—the well-known Cut-leaved Maple—is a very handsome street tree, because of its bizarre leaves and its drooping habit.

ACER RUBRUM LINNAEUS

Red Maple

Scarlet Maple

The Red Maple is a tree of moderate to large size, with a narrow head of more or less upright branches. The coarsely toothed, usually 5-lobed, light-green leaves, 2 to 6 inches long, are whitened beneath and stand on slender petioles 2 to 4 inches long. The red flowers, which have both sepals and petals, are borne in dense clusters along the previous year's growth, each flower on a long, slender stalk. The small, red, brown, or yellow keys hang from stems 3 or 4 inches long and have thin wings nearly 1 inch long by ½ inch wide. The dark-red, rough-coated seed is about ¼ inch long. The shiny, red twigs, which are marked by white lenticels, bear blunt, dark-red buds ⅛ inch long above the small leaf-scars. The trunk, covered by dark-gray, longitudinally ridged bark that flakes off in large, plate-like scales, attains a diameter of 3 feet or more, and the tree grows commonly to a height of 50 feet or, in favorable situations, even 100 feet.



FIG. 100. Distribution of the Red Maple.

Distribution: A tree of streams, swamps, and forests, the Red Maple ranges from Newfoundland to Florida and westward to Iowa and Texas. It is generally considered the commonest and most widely distributed tree in eastern North America, but in Illinois it is the least abundant of our maples. Though its range includes the entire State, it is not common in the north and is hardly more abundant, though more often collected, in the south. On mixed loam soil at Allendale, Wabash County, one of the finest trees had, at 90 years of age, attained a height of 101 feet and a diameter of 24 inches inside the bark.

In the northern part of the State, the Red Maple occasionally occurs in pure stands on the borders of streams and lakes, and Pepoon¹ remarks that it is abundant in the wet woods at Edgebrook. In northern situations its chief associate is the

Black Ash. In Cumberland County it forms an understory on the Pin Oak flats and is associated also with the Shingle and Swamp White oaks, the Green Ash, and the Honey Locust. In Williamson County it grows with Elm and Hackberry, and still farther south its associates are Red Gum, Cypress, Cottonwoods, and the bottomland oaks.

Two varieties of Red Maple occur in Illinois. Through the southern third of the State, *Acer rubrum Drummondii* Sargent is fairly frequent. It differs from the species in several respects, chiefly in having hairy twigs, leaves with woolly under-sides, and very large keys, which may reach a length of 2½ inches. This is preeminently a swamp-inhabiting tree and has been collected in Richland County by Robert Ridgway, in Richland, Jackson, and Wabash counties by H. Teuscher, and in Pulaski County by C. J. Telford. The variety *tridens* Wood has been found in Richland County by Robert Ridgway and E. W. Mattoon, and in Pulaski County, near Karnak, by C. J. Telford. It differs from the species particularly with regard to its leaves, which are distinctly 3-lobed, remotely toothed, and hairy beneath.

¹ Flora of the Chicago Region, p. 378.



PLATE 83

ACER RUBRUM LINNÆUS

RED MAPLE



PLATE 84

ACER NEGUNDO LINNAEUS

BOX ELDER

and the borders of swamps, the Box Elder ranges from Vermont westward to Minnesota and southward to Florida and Texas. Through most of Illinois it is to be found in low woodlands and other moist situations. It is a very common escape from cultivation along hedge rows and fences, where the nearby roadside ditches undoubtedly favor its growth. It attains its best growth in the southern part of the State. On the Big Muddy bottomlands in Williamson County, it grows in company with Elm, ashes, White Oak, Water Locust, and hickories; and in Union County with Soft Maple, Elm, ashes, Pecan, Willow, and Pin Oak.

Uses: The creamy-white, close-grained wood of the Box Elder is neither hard nor strong. Its poor technical qualities render it rather useless, though it has been employed to some extent in the making of cheap furniture, for the inferior finish of houses, where its whiteness may be used with a decorative effect, and in the manufacture of cooperage and wooden wares of various kinds.

Maple sugar can be made from Box Elder sap; and the tree has been used extensively for shade, though the brittleness of its branches renders it very susceptible to damage from storms and sleet. A cultivated variety with variegated leaves is used for decorative planting.

AESCULUS LINNAEUS . Buckeye

Family HIPPOCASTANACEAE

Small or large, deciduous trees, with opposite, compound leaves consisting of 3 to 9 feather-veined, toothed leaflets arising together from the end of the petiole. Flowers rather showy and colored, in upright racemes on the end of the branchlets, each flower with 5 sepals and 4 or 5 petals, 6 to 8 stamens, and a 3-celled ovary, which is rudimentary in the staminate flower. Fruit a rough or smooth, woody capsule that splits into 3 parts to liberate 1 to 3 pressure-flattened, globular seeds, each of which is marked by a large light scar. Stout, round twigs with somewhat angular, pale pith and very large, scaly buds set above low, more or less triangular leaf-scars. Bark variable in character, but bitter.

This genus, with its 16 species, is widely distributed in the Northern Hemisphere. In North America there are 6 species, which are most abundant and range, chiefly, through the southeastern part of the United States. But one species extends its range northwestward into Illinois.



PLATE 85

AESCULUS GLABRA WILLDENOW

OHIO BUCKEYE

AESCULUS GLABRA WILLDENOW

Ohio Buckeye

Fetid Buckeye

The Ohio Buckeye, also known as the Fetid Buckeye, is a tree of considerably less than medium height, with a broad, long, round-topped crown of small, spreading branches. Each leaf consists of 5 long-oval, pointed, toothed, yellow-green leaflets set like the fingers of a hand at the

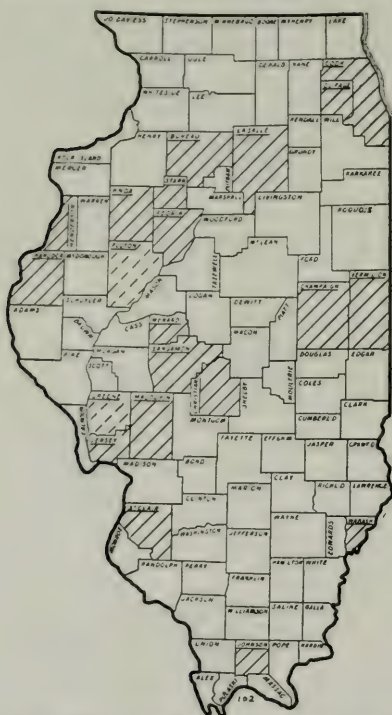


FIG. 102. Distribution of the Ohio Buckeye.

top of a slender petiole 4 to 6 inches long. The pale, yellow-green flowers stand in rather dense, upright, conical racemes, at the ends of the branchlets. The fruit incloses within its sharply warty, brown shell from 1 to 3 shiny, brown, dark seeds usually an inch or more in diameter. The red-brown branchlets, which are covered at first with fine hair, are marked by scattered, orange lenticels and bear large buds, $\frac{1}{2}$ to $\frac{3}{4}$ inch long above large leaf-scars. The trunk, which is covered by dark-brown to gray, fissured, scaly bark, attains a diameter in proportion to the height of the tree, which is not often more than 30 or 40 feet.

Distribution: Along the banks and on the bottomlands of rivers and streams, the Ohio Buckeye ranges from Pennsylvania southwestward to Alabama, Kansas, and Nebraska. Excepting only a region in the northwest corner of Illinois, it ranges quite generally

through the wooded stream lands of the State, preferring especially the moist sides of low bluffs but growing also on the bottomlands. In these woodlands it is, however, to be counted as among the occasional rather than the common trees. Its associates are Soft Maple, ashes, Cottonwood, Elm, Sycamore and, very often, various haws.

Uses: Though close-grained, the light wood of the Buckeye is both weak and soft. When it is cut, it is sold on the market as bass wood, which it resembles both in its whiteness and the ease with which it can be worked. Its uses include chiefly manufactured articles such as wooden ware of various kinds, drawing boards, artificial limbs, and paper pulp.

TILIA LINNAEUS**The Lindens**Family **TILIACEAE**

Small to very large, deciduous trees, with alternate, 2-ranked, broad-bladed, toothed leaves and white or yellow, fragrant, nectar-bearing flowers borne in clusters toward the end of a stalk which arises from the mid-vein of a large, leaf-like structure. Fruit a nut-like, globular, woody body, hairy on the outside and containing 1 or 2 light reddish-brown seeds. Twigs zig-zag, with fibrous bark, pale pink or yellowish pith and red or green buds above nearly half-round leaf-scars. Bark tough and fibrous.

Tilia, with its 30 species, ranges throughout most of the temperate regions of the Northern Hemisphere, with the exception of western North America and central Asia. Though not as ancient as many of our trees, its known fossil forms include perhaps 30 species. It always has been one of the most highly valued trees. To primitive man, its flowers yielded, as they still do, honey of the finest flavor and lightest color; the wood served the homeliest uses, being made into such necessary articles as ox-yokes; and the bark yielded fibers for making cords and ropes.

There are 15 native American species, four of which are reported to occur in Illinois. So far as may be judged from the specimens at hand and the observations of our forest survey, three of these are rare, the well-known Bass Wood being the common tree. The following key will serve to distinguish them, though only the common species is described.

KEY TO THE ILLINOIS LINDENS

Leaves velvety or woolly beneath.....**T. heterophylla** Michauxii Sargent

Leaves smooth or only hairy beneath.

Leaves very large, 5 to 6 inches long.....**T. glabra** Ventenat

Leaves generally smaller, 3 to 5 inches long.

Leaves pale but smooth beneath.....**T. floridana** Ashe

Leaves covered with short hairs beneath.....**T. neglecta** Spach

TILIA GLABRA VENTENAT

Bass Wood

Linden

The Bass Wood, or American Linden, is ordinarily a tree of moderate height, with a broad and round-topped crown of small and somewhat drooping branches. The broadly oval, slenderly pointed, coarsely toothed leaves, 5 or 6 inches long by 3 or 4 inches wide, dark-green and dull on

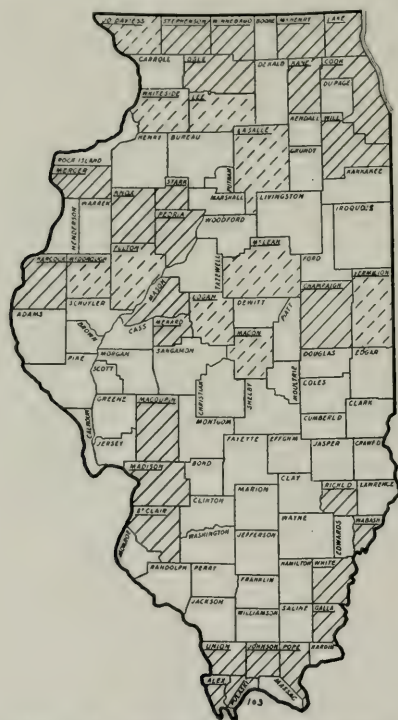


FIG. 103. Distribution of the Bass Wood.

the upper face, lighter and shiny beneath, stand on slender petioles $1\frac{1}{2}$ to 2 inches long. The sweetly fragrant, yellowish-white flowers hang in clusters of 5 to 20 on a long stalk, which arises from the middle of the mid-vein of an axillary, oblong, leaf-like structure. The woody, globular fruit, nearly $\frac{1}{2}$ inch in diameter, is densely hairy outside. The brown branchlets bear dark-red buds about $\frac{1}{4}$ inch long; and the trunk, inclosed by thick, brown, deeply furrowed bark, may become 3 feet thick, while the tree attains a height of 60 feet or more.

Distribution: On rich, moist soils, the Bass Wood ranges from New Brunswick westward to Winnipeg and southward to Pennsylvania, Kentucky, and Nebraska. It ranges throughout Illinois and may be found wherever rich, wooded slopes, moist stream banks, and cool ravines occur.

Among the large number of its associates are the White, Black, Red, and Burr oaks, hickories, the White and Slippery elms, maples, ashes, Black Walnut, Wild Black Cherry, and Tulip Tree. It grows to its largest size on the bottomlands of the Ohio River.

Uses: Though light in weight, the red-tinted, light-brown wood of the Bass Wood is strong and especially suited for such articles as high-grade boxes and crates. Being very easily worked with tools, it is a favorite wood of cabinet makers and manual training teachers. It is not by any means durable and cannot be used for rough building, ties, or fence posts, with the certainty of more than 3 to 5 years of service. Small



PLATE 86

TILIA GLABRA VENTENAT

BASS WOOD

quantities are used for fuel, though the heating quality is inferior to both beech and oak. Under the name "white wood," however, bass wood is manufactured into a great variety of articles, including cheap furniture, trunks, boxes, musical instruments, picture mouldings, laundry appliances, and beekeeper supplies, as well as paper pulp, veneers, and excelsior. In lumber cut from the butt of the tree, there often is a curly grain, which gives an attractive appearance in cabinets.

NYSSA LINNAEUS**The Tupelos**

Family NYSSACEAE

Moderate to large, deciduous trees, with alternate, crowded, entire, broad-bladed leaves and tiny, greenish-white flowers. Staminate and pistillate flowers separate, the former in globular clusters, the latter a few together on the ends of long, slender pedicels which arise from the axils of the leaves. Fruit a fleshy, oval drupe containing a thick-walled, bony, variously roughened pit. Twigs rather stout, with diaphragmed white pith and with oval buds set in the notch of crescent or U-shaped leaf-scars. Bark gray to brown, furrowed, and roughened with scales.

Besides the four species of southeastern North America, there are but two other Tupelos, one a native of central China, the other native to southern and eastern Asia. Though now so limited both in the variety of its forms and the wideness of its distribution, *Nyssa* is an ancient genus, the history of which goes far back into our knowledge of the world's life. Previous to the glacial period, as fossils show, it was not only widely distributed throughout what are now the North Temperate and Arctic zones but was also possessed of a much greater variety of forms, no less than 30 of which have been found as fossils. In Illinois, at the present time, we have but 2 species.

KEY TO THE ILLINOIS TUPELOS

- Leaves 2 to 5 inches long; on moist but not inundated soils...*N. sylvatica* p. 256
Leaves 5 to 7 inches long; on inundated, swampy lands.....*N. aquatica* p. 257



PLATE 81

NYSSA SYLVATICA MARSHALL

TUPELO

NYSSA SYLVATICA MARSHALL

Tupelo

Sour Gum

The Tupelo is a tree of somewhat more than moderate height, with a long, narrow crown of slender, rather drooping branches capping the straight trunk. The firm, shiny, dark-green leaves, 2 to 5 inches long by 1 to 3 inches wide, stand on round or winged petioles $\frac{1}{4}$ to $1\frac{1}{2}$ inches long.

The staminate flowers, capping slender, hairy pedicels sometimes $1\frac{1}{2}$ inches long, are in dense, globular heads, while the pistillate flowers, on separate pedicels, occur only in two's and three's. The fruits, 1 to 3 in a cluster at the end of a pedicel, are dark-blue, about $\frac{1}{2}$ to $\frac{3}{4}$ inch long, and contain a light-brown, ribbed stone. The light red-brown branchlets, marked by pale lenticels, bear blunt, dark-red buds above lunar leaf-scars. The trunk, covered by red-tinted, brown, deeply fissured bark, has a diameter proportionate to the height of the tree, which varies according to situation from 30 or 40 feet to more than 100 feet.

Distribution: On wet, poorly drained soils and the edges of swamps, the Tupelo ranges from Maine to Florida and westward to Texas and Missouri. In Illinois, it is now distinctly a southern tree, coming up the

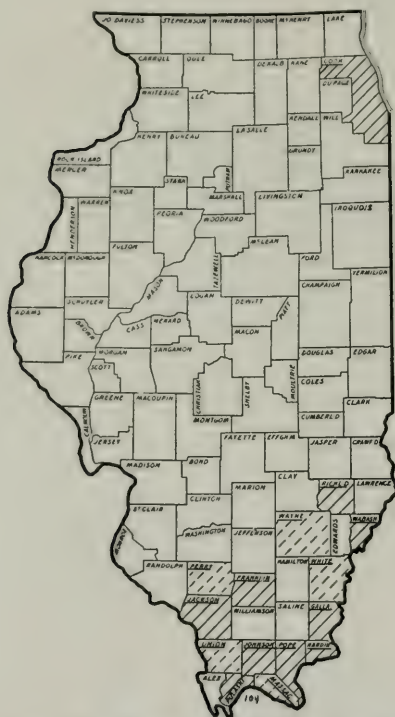


FIG. 104. Distribution of the Tupelo.

eastern side of the State as far as Richland County and up the western side into Perry County. The record of its occurrence to the north, in Cook County, is based on some fine trees, now completely destroyed, which grew in a small swamp near Rogers Park previous to 1910. In southern Illinois, the Tupelo is not confined entirely to low or swampy situations, but is seen not infrequently on hills and dry slopes. It has a large list of associated trees, among which are numerous oaks and hickories, White Elm, ashes, River Birch, Wild Black Cherry, Sycamore, and Red Gum.

Uses: Though heavy, strong, and very tough, the wood of the Tupelo is neither hard nor durable. Exceptional care must be used in seasoning it, because of a pronounced tendency to warp and twist. By the pioneers, who used the hollow trunks for "bee-guns," Tupelo was looked upon as a weed tree; but it is now used very extensively in manufacturing the veneers from which egg crates are made. The toughness of the wood also has led to its being used for such articles as wheel hubs, gun stocks, rollers, mallets, and rough flooring, while a certain small amount furnishes charcoal and pulpwood as well as fuel.

NYSSA AQUATICA MARSHALL

Tupelo Gum

Cotton Gum

The Tupelo Gum is a tree of rather more than moderate height, with a wide and buttressed trunk, above which rises a straight bole capped by a narrow, oblong crown of rather small, spreading branches. The shiny, dark-green, firm leaves, 5 to 7 inches long by 2 to 4 inches wide and sometimes slightly toothed on the margins, stand on stout, hairy petioles 1 to 3 inches long. The dense, globular clusters of staminate flowers cap their slender pedicels, while the pistillate flowers stand alone on the ends of much shorter pedicels. The dark-purple, conspicuously dotted fruits, nearly an inch long, have thin, sour flesh inside their thick, tough skins, and a flattened pit with 10 wing-like ridges occupies the center. The stout, dark-red branchlets



FIG. 105. Tupelo Gum on the Cache River bottoms in Massac County. The swollen, buttressed bases are characteristic of trees inhabiting flooded lands.

bear tiny, blunt buds nearly imbedded in the bark above the conspicuous, nearly round leaf-scars. The trunk, which is covered by dark-brown, furrowed, scale-roughened bark, becomes 3 or 4 feet thick above the buttressed base; and the tree attains a height of 80 feet or more.

Distribution: From Virginia southward to Florida, westward to Texas, and again northward into the lower valley of the Wabash River, the Tupelo Gum is an inhabitant of low, inundated swamps. Its range



PLATE 88

NYSSA AQUATICA MARSHALL

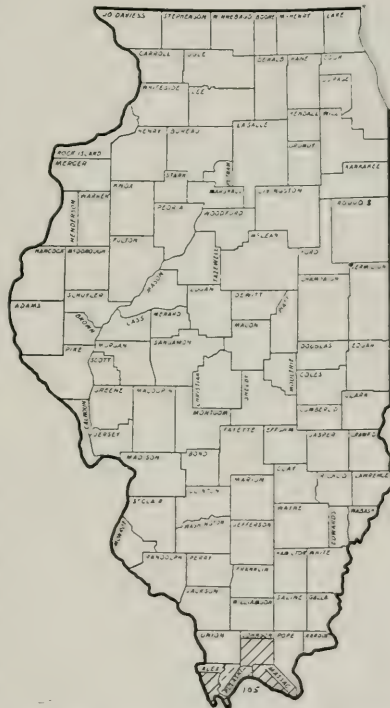
TUPELO GUM

in Illinois is confined to four counties in the southern tip of the State, but even in this region it does not occur outside of the Cypress swamps. Its chief associates are Cypress, Soft Maple, and Black Cottonwood.

Uses: Though close-grained and difficult to split, the light-brown to nearly white wood of the Tupelo Gum is light, soft, and weak. Its best grades resemble yellow poplar, as it has a fine, uniform texture and, though tough, is easily worked with tools. Much care is required in seasoning the lumber; but the wood takes paint and varnish well and is used for house-flooring and interior finishing. The poorer grades of tupelo gum furnish material for boxes and egg crates, and timbers and planks are used extensively as flooring for depots and warehouses, where there is heavy wear on the floors. Though the wood is not durable in the soil, it has proved satisfactory, when treated against decay, for such uses as cross-arms of telephone poles, cross-ties in mines, and wood paving blocks.

In the bottomland Cypress forests of southern Illinois, the Tupelo Gum constitutes between 19 and 20 per cent of the stand. Among 22 species of trees, it stands second only to Cypress, with an average of 16 trees to the acre. Its potential yield, however, is in excess of all species, amounting to 15,000 board feet per acre, or nearly twice the Cypress yield.

In 1910, about 978,000 board feet of tupelo gum was produced in the southern counties of Illinois; but in 1925, the amount had fallen to 102,000 board feet. This may be taken to indicate that the Tupelo Gum, like the other trees of the Cypress swamps, are fast disappearing. Indeed, the largest trees measured in our survey were but 80 feet high and had trunk diameters of only 30 inches.



CORNUS LINNAEUS**Dogwood**Family **CORNACEAE**

Small and generally bushy, deciduous trees and shrubs, with opposite or alternate, entire, broad-bladed leaves and small flowers in loose or dense, terminal heads. Fruit a fleshy drupe with thin, juicy flesh and a hard, often bony pit containing, as a rule, 2 seeds. Twigs rather slender, with more or less angled and sometimes colored pith and with stalked, 2-scaled buds above more or less U-shaped leaf-scars. Bark generally scaly, sometimes fissured.

With its 40 or 50 species, *Cornus* is widely distributed throughout the Northern Hemisphere and extends its range south of the Equator into Peru, where one species is found. Of the 18 North American species, only 4 attain tree size; and 2 of these are common in Illinois. Though not so ancient as many of our trees, more than 50 different species have been identified from fossils; and one of these, with large floral bracts, almost certainly an ancestor of our modern Flowering Dogwood, grew in North America when the polar region was warm and forested and before the ice sheets were formed.

KEY TO THE ILLINOIS DOGWOODS

Leaves opposite; flower heads surrounded by white, petal-like bracts...

C. florida p. 260

Leaves alternate; flowers in loose, branched heads.....**C. alternifolia** p. 264

CORNUS FLORIDA LINNAEUS**Flowering Dogwood**

The Flowering Dogwood is a small, bushy tree, with a flat crown of slender, spreading branches and branchlets up-tilted at the ends. The firm, bright-green, minutely hairy leaves, with oval blades 3 to 6 inches long and 1 to 2 inches wide, are pale beneath and stand on grooved petioles nearly $\frac{3}{4}$ inch long. The dense heads of small, greenish flowers stand, on pedicels 1 to 2 inches long, in white, flower-like cups 3 or 4 inches wide, which are so conspicuous in the early spring as to give the tree its common name. The bright, scarlet fruits, about $\frac{1}{2}$ inch long by $\frac{1}{4}$ inch wide and crowded at the ends of the pedicels, have thin and rather mealy flesh and smooth, hard pits, each containing 1 or 2 pale-brown seeds. The bright-red or yellow-green branchlets terminate in long-stalked, globular buds. The trunk, covered by thin, dark, reddish bark broken into square plates, may

become a foot thick, and the tree may attain a height of 40 feet, though it is not often over 25 feet high.

Distribution: As one of the under-story trees of forests on rich and well-drained land, the Flowering Dogwood ranges from Maine southward to Florida and westward to Kansas and Texas. In Illinois, it occurs in most of our wooded regions, excepting only those in the northeast corner of the State. It is, however, found most frequently in the southern half of the State, where it is associated commonly with Persimmon and Sassafras. Its dark-red autumnal foliage, its beautiful, white flowers in the spring, and its brilliant, red berries give color and character to our woodlands; but in the practice of forestry in our woodlots, it may have to be removed, along with Redbud, Persimmon, Ironwood, and Blue Beech, as its shade is so dense that some more valuable trees cannot gain a foothold.

Uses: The hard, close-grained, brown wood of the Flowering Dogwood is both strong and heavy, and it resembles superficially the wood of the Hard Maple. Through long wear, it becomes highly polished and is, therefore, much used for shuttles, spools, and bobbins in cotton mills. It is a favorite wood for small articles of turnery, and is made also into engravers' blocks, golf-stick heads, brush blocks, and bearings for wooden machines. In the virgin timberland of Union County, Flowering Dogwood now averages about 100 trees to the acre; but the maximum height is only 25 feet and the potential yield only 16 cubic feet to the acre.

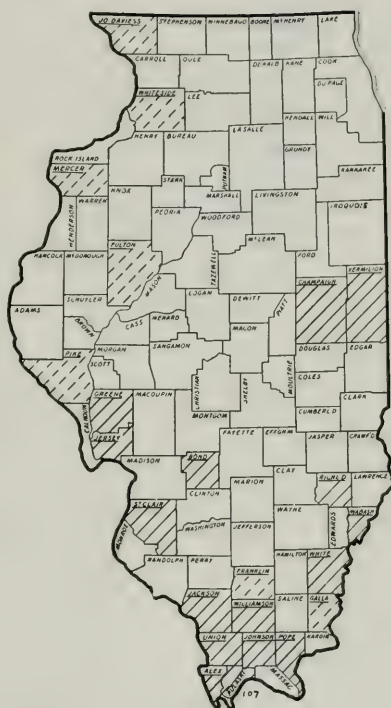


FIG. 107. Distribution of the Flowering Dogwood.



PLATE 89

CORNUS FLORIDA LINNAEUS

FLOWERING DOGWOOD



PLATE 90

CORNUS ALTERNIFOLIA LINNAEUS

DOGWOOD

CORNUS ALTERNIFOLIA LINNAEUS

Dogwood

The Dogwood is a very small tree, with a dense, flat-topped crown of slender, spreading branches. The thin, bright yellow-green, pointed leaves, mostly alternate on the branchlets and 3 to 5 inches long by 2 to 3 inches wide, are pale, hairy, and sometimes nearly white beneath and stand on slender, hairy petioles nearly 2 inches long. The small, creamy-white flowers stand in loose, branched heads on the tips of lateral branchlets. The loose, spreading, red-stemmed clusters of globular, dark-blue fruits ripen in October, each fruit being somewhat less than $\frac{1}{2}$ inch in diameter, with thin, bitter flesh and a thick-walled, many-grooved pit containing 1 or 2 curved, pale seeds. The light-green to brownish twigs bear sharply pointed, chestnut-brown buds above the raised, moon-shaped leaf-scars. The trunk, clothed with thin, reddish-brown bark which is smooth or shallowly fissured and ridged, seldom becomes more than 6 inches thick; and the tree, though arborescent in form, is usually only about 20 feet tall.

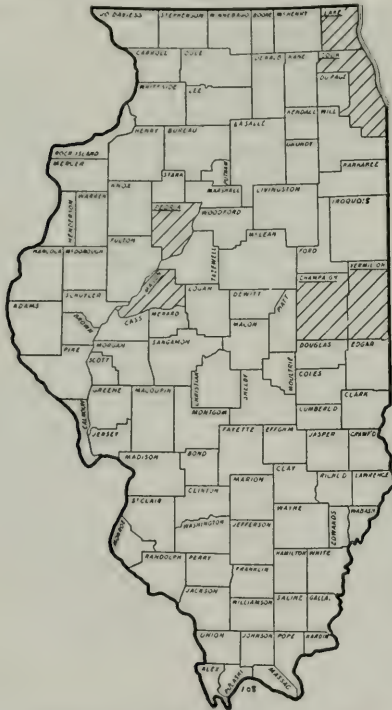


FIG. 108. Distribution of the Dogwood.

Distribution: From Nova Scotia westward to Minnesota and southward to Florida, the Dogwood inhabits the rich soils of the forest edge, stream borders, and swampy swales. In Illinois it is distinctly northern in its range, reaching only as far south as Vermilion, Champaign, and Mason counties. It is particularly common in the lake-shore woods of our northeastern counties, where it grows as a member of the elm-maple association.

Uses: The heavy, red-tinted, brown wood of the Dogwood is both hard and close-grained. In its technical qualities it is comparable to the wood of the Flowering Dogwood and, like it, is used to some extent in the manufacture of small wooden articles. It also yields charcoal. The tree, however, is so small that it cannot be called profitable.

DIOSPYROS LINNAEUS**The Ebonies**Family **EBENACEAE**

Trees or shrubs with leathery, alternate, entire leaves and 4-parted, greenish to creamy-white, bell-like flowers from the axils of year-old leaf-scars. Staminate and pistillate flowers separate, the former the smaller and in few-flowered heads, the latter usually solitary. Fruit a rather large, fleshy, one- to many-seeded berry. Twigs slender and round, with greenish pith and broadly conical buds, each covered by 2 overlapping scales, set close on the flat tops of the nearly half-round leaf-scars. Bark variable.

With more than 200 modern species, *Diospyros* ranges through a great part of the tropical regions of the world; but a few of the species live in the more temperate climates of eastern North America, the lands bordering the Mediterranean Sea, and southern Asia. Varied and widely distributed as it is today, the genus was, in immensely remote ages, at least as varied and certainly far more widely distributed. The fossils that have been found up to the present time show that previous to the great Ice Age the Ebonies lived not only where they are today but even as far north as the northern coasts of Asia and North America and the southern part of Greenland.

Of the 2 North American species, the Persimmon alone grows in Illinois.

DIOSPYROS VIRGINIANA LINNAEUS**Persimmon**

The persimmon is a tree of rather less than moderate height, with a round-topped crown of spreading and somewhat drooping branches. The shiny, dark-green, leathery leaves, 4 to 6 inches long by half as broad, are pale beneath and stand on stout petioles nearly an inch long. The staminate flowers grow, 2 or 3 together, on hairy stalks, while the greenish or creamy-white pistillate flowers are solitary on the ends of short, recurved pedicels. The globular, yellow to orange, bright-cheeked fruit, often 1½ inches in diameter, contains sweet and juicy, yellow-brown flesh which surrounds the flattened, hard-coated seeds. The light-brown to gray twigs, marked with orange lenticels, bear broadly conical, red-brown to purplish buds above the half-round leaf-scars. The trunk, covered by dark-brown to dark-gray bark which breaks up into characteristic, square plates, is seldom over a foot thick, and the tree is ordinarily not more than 25 to 30 feet tall.



FIG. 109. Distribution of Persimmon.

Distribution: The Persimmon grows, in a great variety of situations, from Connecticut in the Northeast to Iowa in the West and to Florida and Texas in the South. In Illinois, it is chiefly a southern tree. Its northern limit is in Peoria County as far as available records show; but it becomes increasingly common southward, and formerly, at least, trees of considerable size grew in the Wabash Valley. Robert Ridgway¹ describes them in the following words: "When growing in the thick bottomland forest, the persimmon is frequently 100 or more feet in height. The tallest specimen measured 115 feet high, 80 feet to the first limb, but only 5½ feet in girth at the base, or less than 2 feet in diameter." No such trees as these have been seen in recent years.

Sometimes the Persimmon grows in small, pure groves, but more often it is mixed with a variety of other trees. In the southern counties, where it frequently invades abandoned fields and eroded lands, it is associated with Sassafras and Sumach, while in the woodlands of the Wabash Valley its commonest associates are Water Locust, Buttonbush, and Swell-butted Ash. Northward, as in Vermilion County, it grows in woods where the White, Black, and Red oaks and hickories are the principal trees.

Uses: Exceptionally high in technical qualities, the dense, hard, heavy wood of the Persimmon is in great demand for wooden articles which must be strong and able to withstand wear. The black heartwood, called American ebony, is used extensively for rollers and the heads of golf clubs. It is preferred above all other American woods for shuttles.

Although the wild trees often furnish excellent fruit, there is considerable variation among them both as to the quality and time of ripening. It is possible, however, to plant selected varieties, or to top-graft the native trees with them, and secure fruit superior in flavor and earlier in ripening.

¹ Proc. U. S. Nat. Mus. Vol. 5, p. 68. 1882.



PLATE 91

DIOSPYROS VIRGINIANA LINNAEUS

PERSIMMON

FRAXINUS LINNAEUS

The Ashes

Family OLEACEAE

Small to very large, deciduous trees, with opposite, mostly compound leaves consisting of an odd number of broad-bladed, toothed leaflets. Stamens and pistils in separate flowers; the inconspicuous flowers 2- or 4-parted, in open or compact, pedicelled, branched heads in various positions on the new growth or from the axils of leaf-scars. Fruit a key with 1, or rarely 2 or 3, much elongated wings and 1 or more brown seeds. Twigs rather stout, with oval pith and often globular, superposed buds set above the broadly crescent-shaped leaf-scars. Bark usually thick, furrowed, and scaly.

With more than 50 species, *Fraxinus* ranges through most of the temperate regions of the Northern Hemisphere, extending into the tropics in Cuba and Java. It occurs in a particular abundance of forms in southeastern North America and southeastern Asia. America appears to have been its first home, and the American trees are usually larger and furnish more valuable wood. Not only is the Ash familiar in the songs and stories and in the superstitions, the joys, and the labors of the human race, but even millions of years before the history of mankind began, the Ash was present in the world, as fossils show, in a great variety of forms and with a distribution stretching from Greenland and Alaska to Louisiana. Some of these ancient Ashes escaped destruction during the Ice Age and are perpetuating themselves today in our forests. The White Ash and the Blue Ash are two such American trees.

The modern North American Ashes comprise 17 species, and 6 of these, with a few distinguishable varieties, inhabit Illinois.

KEY TO THE ILLINOIS ASHES

Twigs round or only slightly angular; buds brown to blackish.

Leaflets without stalks; leaf-scars oval, longer than broad; buds blackish.....*F. nigra* p. 280

Leaflets stalked; leaf-scars more or less lunar; buds brown.

Wings of the keys arising from the upper third of the seed.

Twigs and petioles hairy.....*F. biltmoreana* p. 271

Twigs and petioles smooth.....*F. americana* p. 270

Wings of the keys arising at least half-way down the seed.

Leaflets toothed along at least the upper half of their margins.....*F. pennsylvanica* p. 275

Leaflets not toothed, or only wavy.....*F. profunda* p. 274

Twigs square, with 4 sharp angles; buds gray.....*F. quadrangulata* p. 278



PLATE 92

FRAXINUS AMERICANA LINNAEUS

WHITE ASH

FRAXINUS AMERICANA LINNAEUS

White Ash

The White Ash is a tree commonly of somewhat more than moderate height, with a narrow crown of stout and upright, or somewhat spreading branches. The firm, but thin, dark-green leaves, between 8 and 12 inches long, consist of 7, sometimes 5 or 9, sharply pointed, more or less



FIG. 110. Distribution of the White Ash.

toothed leaflets, 3 to 5 inches long by half as wide, set oppositely in pairs, the odd one terminal, on the stout petiole. The flowers grow in compact or elongated groups from lateral buds. The keys stand in crowded clusters 6 to 8 inches long, each key with its terminal wing, 1 to 2 inches long by $\frac{1}{4}$ inch wide. The gray to brownish branchlets bear dark-brown buds in the hollows of the deeply lunar leaf-scars. The trunk, inclosed by thick, dark-brown, deeply fissured bark with rounded, scaly ridges, becomes 2 or 3 feet thick, and the tree grows to a usual height of 70 or 80 feet.

Distribution: From Nova Scotia, the White Ash ranges westward into Minnesota and Nebraska and southward to Florida and Texas. In Illinois, it grows throughout the State, preferring the moist soils of stream banks and bottomlands, though never occurring in mucky swamps. It never

forms pure stands of any extent, though it often occurs in small groups, which may be gradually enlarged by opening up the area to better light. In Wabash County, near Allendale, where the upland woods have been cut over recently, the associates of the White Ash include Hackberry, Hard Maple, Shellbark and other hickories, Tulip Tree, Bass Wood, Red Gum, Slippery Elm, Black Walnut, and Kentucky Coffee Tree, while nearer the streams Pin Oak and Schneck's Oak also occur. Ridgway measured some White Ash growing in the lower Wabash Valley in 1882, one of which he found to be 110 feet high, 14 feet in trunk circumference, and 79 feet 6 inches to the first limb.

Uses: The hard, close-grained wood of the White Ash is strong and tough. It is used wherever strength and elasticity are required, as in the manufacture of tool handles, oars, paddles, bows for the tops of automobiles and carriages, and axles of artillery carriages and farm wagons. Next to rock elm, white ash is the finest wood obtainable for javelins, and a great many sporting and athletic goods are made of it, such as baseball bats, tennis racquets, and snowshoes. In the manufacture of airplanes, white ash serves ideally for the bent wood of wings and fuselage, for landing skids, and for the framework. In addition, it serves admirably for the interior finishing of houses.

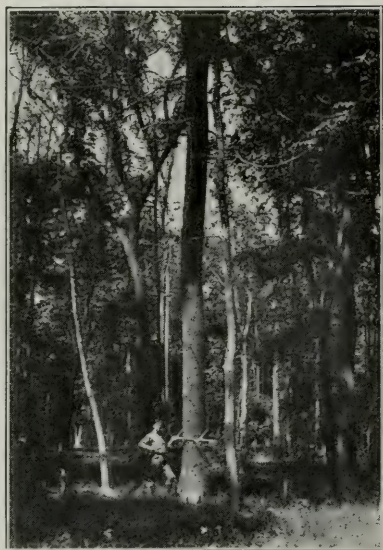


FIG. 111. White Ash growing with oaks and maples southeast of Mendota, LaSalle County.

FRAXINUS BILTMOREANA BEADLE

Biltmore Ash

The Biltmore Ash is a tree of considerably less than medium height with an open head of stout and up-tilted branches. The thick, dark-green leaves, 10 to 12 inches long, consist of 7 or 9 stalked, toothed leaflets, each 3 to 6 inches long and a third as wide, set along the stout, hairy petioles. The flowers stand in compact, lateral clusters, and the keys, when they develop, hang in long clusters, each key, with its terminal wing, measuring $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long by about $\frac{1}{4}$ inch broad. The stout, gray branchlets, always softly hairy during their first summer, bear brown buds above the large, shallowly notched, round leaf-scars. The trunk, inclosed by its rough but shallowly furrowed, dark-gray bark, becomes a foot or more in diameter; and the tree commonly attains a height of 40 or 50 feet.

Distribution: The Biltmore Ash, a tree of low stream sides, ranges from New Jersey southward to Georgia and westward to Missouri. In Illinois, as its general range suggests, it is found only in the southern part of the State, where it occurs so infrequently as to have been collected only in Richland and Gallatin counties.



PLATE 93

FRAXINUS BILTMOREANA BEADLE

BILTMORE ASH



PLATE 94

FRAXINUS PROFUNDA Bush

PUMPKIN ASH

Uses: Although the commercial range of the Biltmore Ash ends to the east of the Illinois line, it is probable that the tree was formerly more abundant in our State. Though its wood ranks a little below that of the White Ash in its technical properties, it is known and sold in the lumber trade as white ash and is used indiscriminately for the same purposes.

FRAXINUS PROFUNDA BUSH

Pumpkin Ash

Swell-buttressed Ash

The Pumpkin Ash is a tree of rather more than moderate height, with a swollen, buttressed trunk, from which rises a slender bole capped by a narrow, open crown of small, spreading branches. The exceptionally large, yellow-green, thick leaves, 10 to 18 inches long, consist of 7, less

often 9, elliptic, smooth- or wavy-margined, stalked leaflets set on stout, woolly petioles, each leaflet 5 to 10 inches long by nearly half as wide. The flower clusters are elongated, and the keys, many together in pendulous clusters are 2 or 3 inches long by about $\frac{1}{2}$ inch wide. The light-gray branchlets bear light reddish-brown buds deeply set in the upper margin of the lunar leaf-scars. The trunk, inclosed in thin, light-gray bark shallowly fissured into broad, scaly ridges, may become 2 feet thick; and the tree may rise to a height of 90 feet or more.

Distribution: A tree limited almost entirely to deep swamps and river bottomlands subject to periodic overflows, the Pumpkin Ash grows only in the valley of the Mississippi River and its tributaries, from Indiana and Illinois southward to the Gulf of Mexico, and in the valley of the Appalachian River in Florida. As its



FIG. 112. Distribution of Pumpkin Ash.

range is distinctly southern, it occurs in Illinois only in the southern third of the State, coming northward in the east to Richland County, in the west to St. Clair County, and extending inland along the Cache and Big

Muddy rivers to Johnson and Franklin counties. Its associates in this region include especially the lowland oaks and the Hard Maple. In Pulaski County, the Pumpkin Ash varies in height from 69 to 98 feet, with a corresponding variation in trunk diameter from 16 to 26 inches, and the age of the trees ranges between 80 and 105 years. Northward, on the Big Muddy bottomlands of Franklin County, the height of the Pumpkin Ash is from 67 to 91 feet, the diameter from 10 to 19 inches, and the age from 38 to 76 years.

Uses: Though similar in many respects to white ash, the wood of the Pumpkin Ash lacks its hardness and toughness and cannot be used for such purposes as tool handles, oars, and farming implements. But its fine grain and its slow growth make the wood desirable for crates and boxes, as a source of charcoal, and for paper pulp, while some is used also as fuel.

FRAXINUS PENNSYLVANICA MARSHALL

Red Ash

Green Ash

The Red Ash is a small to moderate tree, with an irregular but compact crown of stout, upright branches. The light, yellow-green leaves, 10 to 12 inches long, are made up of 7 or 9 thin but firm, oval, stalked leaflets, each 4 to 6 inches long by 1 to 2 inches broad, set along the stout, hairy petioles. The flowers are borne in greenish- or purplish-red clusters, the staminate and pistillate flowers usually on separate trees. The keys, with their long, slender seeds and thin wings, are from 1 to 2 inches long by $\frac{1}{4}$ to $\frac{1}{2}$ inch wide. The ashy-gray to brownish twigs bear small, brown buds set in a shallow indentation on the upper margin of the half-round leaf-scars. The trunk, inclosed in red-tinted, brown bark slightly furrowed and scaly on the surface, may become 18 inches thick; and the tree usually attains a height of 50 or 60 feet.

Distribution: On the low, moist plains along rivers and



FIG. 113. Green Ash in the Forest Tree Plantation at the University of Illinois. The plantation dates back to 1871. Photo from the U. S. Forest Service.



PLATE 95

FRAXINUS PENNSYLVANICA LANCEOLATA SARGENT

GREEN

about lakes, the Red Ash ranges from Nova Scotia southward to Georgia and westward to Kansas and Mississippi. It is found in Illinois along all the rivers except the low, swampy streams of the far south, but is neither so common nor so widely distributed as the varietal form *lanceolata* Sargent, known as the Green Ash. The variety is distinguished with difficulty from the species by its bright-green leaflets, which are more sharply toothed, and its taller, more robust growth. The distribution shown in the accompanying map includes both the species and the variety. The Red and Green ashes are found together in greatly differing habitats; for example, in the Wabash Valley they occur on the borders of ponds, on river bottoms, and on swampy land, while farther north, as in Champaign County, they grow on upland soils in rather dry situations. Their moist bottomland associates include Cow and White oaks, Sycamore, Persimmon, cottonwoods, and maples; on drier bottomlands they grow with gums, Cow, Red, and Swamp White oaks, Pecan, hickories, Slippery and Cork elms, River Birch, cottonwoods, and Cypress; and on drier plains with White Elm, Hackberry, Sycamore, Wild Black Cherry, and Burr oak.

Uses: The hard but coarse-grained wood of the Red and Green ashes, though handled commercially as white ash, is not so tough and, being more brittle, has not so wide a range of uses. It is employed chiefly in the manufacture of farming implements, carriage and automobile bodies, and furniture.

The Green Ash has been planted extensively as a shade tree, but it is subject to serious injury by the oyster-shell scale and cannot be recommended as a durable ornament.



FIG. 114. Distribution of the Red and Green Ashes.



PLATE 96

FRAXINUS QUADRANGULATA MICHX

BLUE ASH

Uses: The brown-streaked, light-yellow wood of the Blue Ash, close-grained and hard, is both heavier and denser than the wood of the White Ash, though the lumber from both trees sells as white ash. The Blue Ash wood is, however, rather brittle, and for such purposes as beams, where strength is the first requirement, it is inferior to both white and green ash. But for other purposes, such as flooring, carriage and automobile tops, and the like, it is as useful as the wood of other ashes. Formerly, a blue dye was obtained from the inner bark of the Blue Ash, but its manufacture and use have been superseded largely by the more recent aniline dyes and certain vegetable dyes.

FRAXINUS NIGRA MARSHALL

Black Ash

Brown Ash

The Black Ash is commonly a tree of rather more than moderate height, with a narrow, shallow crown of many up-tilted branches capping its tall, clean bole. The dark-green leaves, between 12 and 16 inches long, are made up of 7, 9, or 11 small-toothed leaflets, the lateral leaflets

being set directly on a stalk sometimes an inch long. The flower clusters, usually nearly terminal on the year-old growth, are 4 or 5 inches long. The keys, their wings inclosing the seeds, are 1 to 1½ inches long by a little more than ¼ inch wide, and they hang in loose, open clusters 8 to 10 inches long. The ashy-gray to orange twigs bear blunt buds above the oval leaf-scars. The trunk, covered by thin, red-tinted, gray bark irregularly plated and separating into papery scales, attains exceptionally a diameter of 18 inches; and the trees become 70 or even 100 feet high.

Distribution: From the Gulf of St. Lawrence westward across Canada to Lake Winnipeg and southward to West Virginia and Arkansas, the Black Ash grows on low, swampy stream-banks and in deep swamps. It is, as should be expected, an un-



FIG. 116. Distribution of Black Ash.



PLATE 97

FRAXINUS NIGRA MARSHALL

BLACK ASH

common tree in Illinois and is to be found only in swampy situations. Its common associates to the north of Illinois are the swamp-inhabiting conifers, but in our State it is associated entirely with deciduous trees.

Uses: The Black Ash is far too rare in Illinois to be counted as commercially valuable, though it is an important timber tree in Wisconsin and Michigan. Though rather soft and weak, its wood is tough and durable and has a large variety of uses, among which are furniture, cabinet making, veneers for crates and baskets, interior finishing of houses, cooperage, and laundry, creamery, and refrigerating appliances. The Indians knew that by pounding the wood they could separate it, along the annual layers, into thin strips, which they used for making baskets; and they called the Black Ash the Basket Tree.

CATALPA SCOPOLI

Family BIGNONIACEAE

Moderate to very large, deciduous trees, with large, heart-shaped leaves borne oppositely in pairs or in whorls of three. Flowers large, rather showy, and spotted inside, borne in terminal, branched clusters. Fruit a long, narrow, pod which splits into halves to liberate numerous brown to gray, winged, hairy seeds. Twigs stout, with large, round pith and with globular buds set above round to oval leaf-scars, there being 2 large and 1 small leaf-scar at each node. Bark thin and scaly.

Catalpa, with 7 species, occurs in southeastern North America, eastern China, and the West Indies. Though now embracing comparatively few forms, with only a limited distribution, this genus is known from fossils to have flourished widely through the ages from a time antedating the Ice Age by many centuries. There are 2 modern American species, one of which, the Indian Bean, with a range to the south and east of Illinois, has been planted extensively as a decorative tree, while the native Illinois catalpa has been employed more often as a timber tree.

CATALPA SPECIOSA ENGELMANN

Catalpa

The Catalpa is usually a tree of only moderate height, though it sometimes becomes exceptionally tall, with a round-topped but narrow crown of slender branches. The firm, dark-green, pointed leaves, nearly a foot long and more than half as wide, are heart-shaped and stand on stout



PLATE 98

CATALPA SPECIOSA ENGELMANN

CATALPA



FIG. 117. The Chicago, Burlington and Quincy railroad's Catalpa plantation at Gladstone, producing fence posts at 17 years old.

petioles 4 to 6 inches long. The bright, purple-spotted, white flowers, each about 2 inches long, stand in open, few-flowered clusters. The thin-walled pods, 8 to 20 inches long but only a little more than $\frac{1}{2}$ inch wide, contain a number of light-brown seeds. Each seed is about 1 inch long by $\frac{1}{4}$ inch wide and is inclosed by 2 terminal wings, from the ends of which a fringe of short hairs extends.

The orange to reddish-brown twigs bear chestnut-brown buds above the oval leaf-scars. The trunk, covered by rather thin, red-tinted, brown bark broken into thick scales, is short and usually not more than 2 feet in diameter, though it may grow to a much larger size; and the tree, usually less than 80 feet tall, may attain heights in excess of 100 feet.

Distribution: Naturally an inhabitant of bottomlands, the Catalpa ranges throughout the wet floodplains and swampy riversides of the Mississippi valley from southern Illinois to Tennessee and Arkansas. Its extreme northern station in Illinois is in Richland County, and from this point it becomes increasingly common as it follows the Wabash River southward to the Ohio, and thence to the Mississippi. The usual dimensions of the larger Catalpas in the Wabash Valley range between 70 and 90 feet for height and between 2 and 3 feet for trunk diameter. Its associates are chiefly Pin Oak, Sweet Gum, Sugarberry, Big Shellbark, Hickory, and Pecan, though in Gallatin County it grows also with White Oak, Red Gum, ashes, Honey Locust, and White Elm.

Uses: The light-brown, coarse-grained wood of the Catalpa, with its thin, nearly white sapwood, is neither heavy nor strong nor hard, and though occasionally employed in the manufacture of furniture and in finishing the interior of houses, its common uses are limited to much rougher purposes. Its durability in the soil is exceptional, and on this account it is used chiefly for fence posts and poles. A Catalpa in Richland County, which was cut in 1900, yielded 247 fence posts, though the entire stump and trunk were hollow.

Catalpa has become an extensively, though often unsuccessfully, cultivated tree, from which the only expected yield is posts; and some rail-

roads now produce the posts for their right-of-way fences by growing this tree for the purpose. From seedling to post size requires between 15 and 20 years of growth, during which time the trees, unless carefully pruned and cultivated, are continually in danger of destruction by the larvae of the *Catalpa Sphinx* Moth and a brown-rot fungus which enters the tree through the dead, unpruned branches and rots the wood. Soil, also, is an important consideration; for on poor, sandy, or gravelly soils this tree will not make a satisfactory growth. In Stark County, a plantation situated on good prairie soil has yielded posts and stakes after 15 years, producing wood at an average rate per year of 162 cubic feet per acre and returning, thereby, a good rate of interest on the investment.



FIG. 118. Distribution of the Catalpa.

LIST OF MINOR VARIETIES AND SPECIES OF TREES
REPORTED TO OCCUR IN ILLINOIS

Acer Negundo violaceum Kirch. The opinion of E. J. Palmer, as expressed in correspondence, is that this is the common Box Elder in Northern Illinois.

Acer nigrum Palmeri Sarg. A specimen in the Field Columbian Museum collected by Agnes Chase (No. 1758) in woods at New Lenox May 7 and September 22, 1902, has been determined as this variety by H. Teuscher.

Acer rubrum tomentosum Kirch. There are 2 specimens in the University of Illinois herbarium, one from Herod, Pope County, the other from Mt. Carmel, Wabash County.

Aesculus discolor Pursh. Represented by a single specimen in the Morton Arboretum. The locality is in Pope County.

- Carya glabra megacarpa* Sarg. In the Arnold Arboretum there are 2 specimens, one collected by E. J. Palmer in Gallatin County, the other by B. F. Bush in Johnson County.
- Carya ovalis obcordata* Sarg. Specimens in the Arnold Arboretum show that this variety has been found in Gallatin, Johnson, Pope, Richland, and Union counties.
- Carya ovalis obovalis* Sarg. Arnold Arboretum specimens have been taken from Richland, Wabash, and White counties.
- Carya ovalis odorata* Sarg. Specimens in the Arnold Arboretum came from Richland, Johnson, and Wabash counties.
- Carya ovata Nuttallii* Sarg. A specimen collected in Johnson County by E. J. Palmer is deposited with the Field Columbian Museum.
- Carya ovata pubescens* Sarg. has been collected in Pope and Richland counties by Robert Ridgway and in Gallatin County by E. J. Palmer. The specimens are in the Arnold Arboretum collection.
- Celtis occidentalis crassifolia* A. Gray. Represented at the Arnold Arboretum by specimens taken in Alexander, Gallatin, Jackson, Richland, and Pope counties, and in the University of Illinois herbarium by specimens from Richland and Kane counties.
- Celtis occidentalis canina* Sarg. Specimens from Richland and Johnson counties, collected respectively by E. J. Palmer and B. F. Bush, are deposited with the Field Columbian Museum.
- Celtis pumila* Pursh. A specimen from Richland County, collected by Robert Ridgway, is in the University of Illinois herbarium.
- Cladastris lutea* Michaux. A typical specimen collected by R. B. Miller near Olive Branch, Alexander County, is deposited in the University of Illinois herbarium.
- Diospyros virginiana platycarpa* Sarg. "This variety with subcordate pubescent leaves and larger earlier ripening fruit is found with the species in southern Illinois."—E. J. Palmer, in correspondence.
- Fagus grandifolia carolinica* Fern. & Rehd. A specimen collected in the chestnut grove in Pulaski County by William Trelease is deposited in the University of Illinois herbarium.
- Quercus alba pinnatifida* ———. A specimen determined by William Trelease is in the Field Columbian Museum's collection. It was collected at Fountaindale by M. S. Bebb and was called by him variety *repanda*.
- Sassafras officinale albidum* Blake. A typical specimen, collected by A. Stanley Pease at White Heath, Piatt County, is in the possession of the Arnold Arboretum.

Botany and Forestry

For students and for teachers, whether they are in collèges, high schools, or academies, and for everyone with a real interest in trees, there is an opportunity to do work of scientific value in almost every region in Illinois. A glance at the maps which indicate the distribution of the trees described in the preceding pages will show how very imperfect is our knowledge of the exact range, the local habitats, and the particularly interesting isolated and local occurrences of even our most common trees. This is a kind of information that can be obtained only with the greatest labor and expense when done at public cost; but with the help of enthusiastic tree lovers a great deal can easily be accomplished toward filling in the gaps in our present knowledge.

THE BOTANY OF TREES

It is not necessary for one to travel widely in order to learn about trees. The home county, so accessible in every part in these days of automobile travel, always contains a surprisingly large number of trees of different kinds. Somewhere there is almost certain to be a stranger, removed from its usual range, which has persisted and perhaps multiplied. Instances of this kind are not too frequent, but when they are found they afford an indescribable satisfaction to the discoverer. It is one of the tree enthusiast's greatest delights to be able to show that a tree does grow beyond the range given it by technical botanists, and in this he is justified, for he has succeeded in making the world's store of knowledge just a little greater.

Neither will the lover of trees find it necessary to spend his money lavishly, in order to enjoy his avocation. His first need is a good book to use as a guide in becoming familiar with the trees, their names, and their habits. Thereafter, his only requirements will be a quantity of old newspapers, between which to press and dry the specimens he collects, a note-pad and pencil to record his observations, a corner of a room at home, where he may keep and study his collections, and such books as his particular interests thereafter demand.

Collecting tree specimens: So prone to error are humans, that botanists have made a rule for themselves, which ought to be adopted by every person who plans to make more than a superficial study of trees. This rule is, that in every case where a tree is found a specimen of it must

be taken and preserved as a positive proof of its existence in that place. The custom amongst botanists is to secure a rather large specimen, so that after it has been dried it can be divided into two or three portions, one of which the collector keeps for himself, sending the others to be deposited in large herbaria. The result is that a permanent record is kept, not only in the collector's personal possession, but also in one or more places open to all students; and if by chance his own collection is destroyed by fire or some other hazard, the results of his labors are still preserved. Moreover, our knowledge of the classification of trees, of their relationships to one another, and of their similarities and differences, is constantly increasing, and there goes with this an equal advance in the differentiating of kinds, the result being that years hence differences among trees will be known to exist where today we can see none. We therefore should preserve specimens for the sake of the students who come after us, in order that they may know exactly, in the light of their fuller knowledge, with what we have dealt. Errors in determining the species of a tree are by no means infrequent, even among trained botanists; and the beginner will find himself very apt to make them, but if he maintains a careful record of his studies in the form of specimens, he will, as he advances in knowledge, be able to retrace his early steps and correct his errors.

The gathering of a specimen is a thing that should always be done with care. Some trees are identified readily by their leaves, some by their flowers, others by their fruits, and still others by their twigs; yet all of these structures, and others besides, which are required to make up the tree, will need to be noticed by the collector. Consequently, he will wish to visit the same tree several times during a year, in order to become familiar with its aspect and characters in the spring when the new leaves and the flowers are coming out, in the summer when it stands fully clothed in green, in the autumn when its fruits are ripe and its foliage is gloriously colored, and in the winter when, devoid of leaves, only its skeleton remains. For each of these seasons, the enthusiastic collector will wish to preserve suitable specimens, so that the things he has learned in the summer will be preserved to him in the winter and in order that he may find foreshadowed in the flowers of spring the fruit of the fall. There is but one criterion to be observed in gathering these specimens, which is that, whether it be flowers, leaves, or fruit, the individual example ought not to be either the largest or the smallest but rather the nearest possible to the average of those that make up the tree.

At the same time that the specimen is secured, notes ought to be made concerning the location of the tree, its size, its probable age, and the

habitat in which it grows. Many experienced collectors have found that they can do this best by keeping a notebook in which these facts are set down in connection with a series of numbers, and the specimens, as they are collected, are marked with the same numbers, so that each specimen and each set of notes will be properly and conveniently connected.

Though many persons have elaborate collecting and drying kits to carry with them on their trips to the woods, the actual necessities are few. For almost everyone, the opportunity to become acquainted with trees will be found on those occasions when a day or an afternoon is given to an outing away from town or away from the duties of the farm; and the specimens that are likely to be collected at such times can be carried home either in the hands or the pockets, or in a small basket. It is best to keep separate the pieces taken from different trees by wrapping them closely in a scrap of newspaper, which will serve also to keep them from wilting unduly.

Drying the specimens: When the specimens have been taken home, they should be placed as soon as possible in a drying apparatus. For this purpose, professional botanists usually have special sets of heavy blotters and often corrugated cardboards and heaters also. But even the most inexperienced person can, with a little care, secure excellent results by using only the old newspapers with which every home is so well supplied. The first thing to do is to cut a newspaper into single sheets the size of the usual page and fold each of these sheets cross-wise. When a sufficient number of them has been provided, the collected specimens should be unwrapped, one by one, and placed within the folded papers, upon the margins of which should be written the identifying numbers. In arranging the specimens, it is well to lay out the leaves and flowers in as natural a position as possible; but one or two leaves should be turned with the lower face outward, so that later when the specimens are studied the characters of both surfaces of the leaves may be compared readily.

In place of the heavy blotters used by botanists, thick pads of newspapers will be found to serve most admirably. One of these newspaper pads should be laid on the floor to serve as the bottom of the pile; on it is laid the first specimen, in its folded sheet; then comes another pad, another enfolded specimen, another pad, and so on, until the fresh specimens all have been arranged in an orderly pile capped by a heavy pad of paper. Now, all that is needed is a board, or a lattice of lathes, of the same dimensions as the folded sheets, which is laid on the top of the pile and pressed down firmly by having several heavy bricks or some other heavy article laid upon it.

At first, the paper pads between the specimens will need to be changed daily, for they absorb water from the plants quite rapidly; and if the stack is left in a damp condition, the specimens are apt to become moldy. As the pressing and drying progresses, changes need be made less often; and when the tree samples are thoroughly dried they can be removed from the dryer and, still folded within the newspaper sheets, tied in convenient bundles for later study.

The personal herbarium: After having taken the pains to collect and dry a number of tree samples, the average person will find a real satisfaction in preserving his specimens in such a way as will allow them to be examined conveniently by himself and his friends. Botanists have developed a method for doing this, which, modified to suit the needs and desires of the individual, will furnish him, in the doing, with many hours of pleasant memories and, when finished, with a collection which he may exhibit with pride and which he will constantly be wishing to increase.

Botanists have found that the most convenient method for preserving a collection is to mount the individual specimens upon sheets of heavy white paper, of such a grade as the individual can afford, the specimens being attached to the paper by glue or by means of small strips of gummed cloth tape. The customary size of these sheets, as used in all the large herbaria, is $16\frac{1}{2}$ inches long by $11\frac{1}{2}$ inches wide. After the specimen has been attached, a label should be pasted to the lower right-hand corner of the sheet, showing not only the name of the tree but also whatever other information may be necessary, such as its collection number, the date and place of collection, whether it is a native or cultivated tree, and notes on its habits of growth. The illustration on the opposite page is a photograph of such a sheet.

To keep the mounted specimens in good condition, some kind of storage is required; and in large herbaria costly metal cabinets are provided; but the individual with a small collection can easily store it at much less expense. If he values it highly he may prefer to purchase nicely finished wooden cabinets, or if he is handy with tools he may enjoy the making of his own cases. The best form of cabinet is one 5 or 6 feet high, with 2 full-length doors on the front, which fit tightly together at the middle of the case. The interior is divided into halves, corresponding to the doors, each half being wide enough to allow the specimen sheets to be placed upon shelves set 5 or 6 inches apart, and the depth of the cabinet corresponding to the length of the sheets.

As the main requirement in providing storage for the specimens is to keep out dust, the ingenious person will not find it hard to substitute



FIG. 119. A PROPERLY PREPARED HERBARIUM SPECIMEN. This specimen of White Ash shows the leaves, a twig, and the mature fruit. A leaf has been turned to show the underside; a small packet has been glued to the lower left hand corner of the sheet to hold the keys that fall off; and the label on the lower right-hand corner gives the name of the plant, the date and locality of collection, and other desirable notes.

other means when cabinets prove too costly. As an example of what may be used, we have found cardboard boxes to be quite satisfactory. We have them made of a substantial grade of cardboard, cloth-bound at the corners, 12 inches wide, 17 inches long and 5 inches deep inside, covered without by a black paper of some neat design, and provided on one end with a brass pull handle and label holder. Each of these boxes will hold 25 or more specimens, and in the quantities in which we have purchased them they have cost between fifty and sixty cents apiece.

For the sake of convenience, the specimens should be sorted so that all those belonging to each genus and each species are together. An added convenience is to have all the sheets for one genus, or all those for one species if the species has been collected several times, laid together in a labeled folder of heavy, serviceable paper. Such folders are usually arranged in the cases by Families, in the order given by some good botanical manual, though for ready reference the genera of each Family are usually placed in alphabetic order.

Insects may be kept away from the specimens by sprinkling them from time to time with naphthaline powder or paradichlorobenzine crystals or by painting them, when they are being mounted, with a saturated solution of corrosive sublimate mixed with alcohol to make it dry quickly. For mice, which are apt to be attracted by seeds and nuts, traps are more dependable and safer than poisons.

Classification of trees: The first need of the amateur student of trees is a means of identifying those with which he is not familiar. This need he is usually able to find supplied in the form of keys, such as those given on pages 15-22, the use of which does not require more than a small amount of botanical knowledge coupled with a little careful observation. But as he progresses in his studies, he will be impressed with the similarities and differences among trees, especially as regards their flowers, their fruits, and their leaves, and he will be impelled to wonder what the significance of these facts may be.

Trees, like all other living things, are supposed to be related to one another, and among them, as among all other living things, size and bulk are of no great significance as an indication of relationships, for these may be judged far more accurately by smaller and often less evident characters. Few people, for example, could be misled after seeing the acorn of the Willow Oak, though the leaves alone might not suggest an oak tree; having once seen the fruit of the Hop Hornbeam, no one would mistake its evident relation to the Birches, though with only the leaves and twigs it might readily be thought an elm; and the Hackberry,

known only by its fruit, would not easily be allied to the elms until its leaves and flowers had been seen. So, among all our trees there are characteristics which, however much the trees may vary otherwise, serve to bring them together into larger and smaller groups of related forms.

All the Illinois trees, however, have one characteristic in common, which is that they all produce seeds as a means of reproduction, and upon this is based the largest and most important botanical division of plants, namely, the Spermatophytes. In contrast with this group, there are others such as the thread-like plants, or Thallophytes, the moss-like plants, or Bryophytes, and the fern-like plants or Pteridophytes. The Spermatophytes themselves are divided into two classes, the Gymnosperms and the Angiosperms.

Gymnosperms: This is an exceedingly ancient, though not an overly large, group of plants. The dense forests of remote geologic periods, the remains of which constitute coal beds, were partly made up of Gymnosperms. This group is represented in the world today chiefly by pines, spruces, and cedars and in Illinois especially by pines, the Tamarack, the Cypress, and the Red Cedar. Our Illinois Gymnosperms are all conifers, which is to say that they bear their seeds in a typical cone; but they do not have flowers in the sense in which flowers are commonly recognized. They have in common, also, the character of long, needle-like leaves, which are usually evergreen. The wood of coniferous trees is generally termed "softwood," and it has in addition a very regular grain, which renders it easy to split.

Angiosperms: This great group of plants contains all of our trees that are not classed among the conifers. Its outstanding characteristic is the production of structures readily recognized as flowers. The tree-size Angiosperms of Illinois are, in addition, deciduous, their leaves are broad-bladed and distinctly veined, and the wood is of the type generally called "hardwood." In this class, there are two botanical subdivisions, the Monocotyledons and the Dicotyledons, the former characterized chiefly by the possession of just one leaf in the seed, as may be seen in the seedlings of wheat or corn, the latter having 2 seed leaves, such as are commonly observed on the seedlings of radishes and beans. Although the Monocotyledons are familiar to us in the form of native grasses and cultivated crops, such as wheat, oats, and corn, none of the tree forms such as Bamboo, Date Palms, and Bananas, occur in Illinois. Our deciduous trees belong, without exception, to the Dicotyledons.

Dicotyledons: Two subdivisions of this class of plants have been recognized generally by botanists, according to the nature of the parts

of the flower. A dicotyledonous tree can be recognized by the fact that the parts of its flowers occur in 4's or 5's (or in multiples thereof), the flower parts of Monocotyledons being commonly in 3's, but it is a fact familiar to almost everyone that the flowers of some trees, such as the willows, hickories, and birches, appear to lack the sepals and petals usually associated with the word flower, while those of other trees, such as the Tulip Tree, Wild Crabs, Plums, and Haws, have all the conspicuous flower parts but keep the individual sepals and petals as distinct and separate members of their flowers. When the flowers are of this general type, the trees possessing them are grouped in a division to which the technical name *Archichlamydae* is applied. But when, as is true with the flowers of the Ashes and Catalpa, the petals are almost completely joined together along the sides, the trees with such flowers are classed in a second and higher subdivision, to which the name *Sympetalae* is given. The first of these two groups contains by far the greater number of kinds of trees.

Further botanical subdivisions: By an even closer examination of the characteristics of trees, they are segregated into several still smaller subdivisions. The largest of these are called Orders, and they in turn are made up of Families, which are still further subdivided into Genera, the Genera into Species, and the Species into Varieties. As a rule, the Genus is the smallest division into which similar kinds of trees are grouped, and the particular kind of tree is known as a Species. All the hickories for example, belong to the genus *Carya*, and each particular kind of hickory is designated as a species under a particular name. The Shell-bark Hickory is known under the name *ovata*, from the shape of its nuts, and its complete name is *Carya ovata*.

Varieties within a species are regarded in various ways, but the most common acceptance of their position is that they are not sufficiently different from species to be regarded as different kinds of trees.

Not being the creators of the plants with which they deal, botanists are by no means agreed as to the exact relationships that exist between plants, and they endeavor to express their different opinions by proposing new or modified classifications. The result is that there are now several prevalent beliefs regarding the most acceptable, the most usable, and the most accurate systems of classifications. To the unexperienced, the prevalence of these different systems, with their accompanying differences in scientific names for certain trees, may seem confusing, but if one accepts at the beginning of his studies the names given by a competent authority and uses them consistently until he is thoroughly familiar with his trees, he will encounter no real trouble.

The economic importance of trees: In addition to the pleasure that one derives from an intimate acquaintance with the kinds of trees and the places in which they grow, the tree enthusiast will, no doubt, find considerable satisfaction in observing the important ways in which they serve mankind. The uses to which trees are put are many and range from the homeliest needs of the farm to purposes of the highest importance to industries. The living trees provide shade and fruit, protect the soil, and conserve the rains. And when they are cut, they furnish many of the necessities of life, including food, shelter, and healing medicines, and there is no human endeavor which does not in some measure depend upon the use of wood or upon articles in the manufacture of which wood has played an important part.

With so varied a range of usefulness, woods must necessarily be selected for each purpose, in accordance with the particular demands to be made of them. For some purposes, wood must be soft, for some it must be hard, for others tough, and for still others strong. The woods of different trees possess these characters in different combinations; and the particular combination for any wood is designated as its "technical qualities."

Softwood and hardwood: It is generally understood that softwoods are derived from pines or other coniferous trees, while hardwoods are produced by deciduous trees. It does not hold true, however, that all softwoods are softer than all hardwoods or that all hardwoods are harder than all softwoods. Like many another of our common expressions, this generalization of the difference between the woods derived from evergreen trees and those derived from deciduous trees is really based on much finer differences.

Structure of wood: When a tree is cut down, the ends of the logs or the top of the stump can be seen to consist of three distinct regions. On the outside, there is the bark; in the center, there is a larger or smaller circle of pith; and intervening between these two is the woody bulk of the tree, from which lumber is sawed. Upon smoothing the roughly sawed end of the trunk with a knife or plane, one sees that the wood is made up of a series of concentric rings—the growth rings which mark the extent of each year's additional growth. And if one looks a little closer, he may observe that much of the central part of the wood is of a dark color, while surrounding it is a narrow zone of lighter color. The first, which serves as a supporting structure for the tree, is the heartwood, while the light wood at the outside, which serves to carry the sap, is called the sapwood. As the tree grows, the sapwood of one year becomes the heartwood of succeeding years, and new sapwood is added to take its place.

One will already have noticed that there are numerous fine streaks or lines radiating from the center of the stump and from each annual ring outward through the wood to the bark. These are the rays, more accurately called medullary rays or pith rays, to which is due the beautiful or striking "silver grain" figures displayed by the lumber from such trees as the oaks, the Sycamore, and the Beech.

The grain of the wood is related especially to the relative width of the annual growth rings and to the longitudinal directions of the microscopic elements, or fibers, which make up the wood. Fine-grained woods come from trees that grow slowly and exhibit narrow rings, while coarse-grained woods are of rapid growth and wide rings. Straight-grained wood is taken from trees that have the wood elements arranged in a perpendicular direction, while spiral or twisted grain results from the wood fibers being arranged in spirals about the axis of the tree. Cross-grained wood, such as is found in the tupelos, Ohio Buckeye, and Sweet Gum, results from the interweaving of the wood fibers; and the wavy or curly grain found in the wood of the maples, ashes, and birches is caused by the wavy growth of the fibers. These variations in grain are important characteristics in determining the uses of woods. Straight-grained woods are generally strong, cross-grained woods are tough, curly-grained woods are both strong and decorative, and coarse- and fine-grained woods are apt to be light and heavy, respectively.

Microscopic structure of wood: In addition to the evident gross structure just described, the wood is made up of numerous kinds of fibers, cells, and ducts, the purpose of which in the living tree is to furnish strength, transfer water and food material from one part to another, and to store reserves of food. These structures differ in different kinds of trees, their particular variation in kind, size, and location being as characteristic of the species as are the flowers, fruits, leaves, and buds. Our commercial woods, as suggested in the paragraph on hardwoods and softwoods, are divided into two classes, upon the microscopic difference between the woods of conifers and of deciduous trees.

If one cuts a log into small, square pieces, or blocks, by sawing crosswise and splitting longitudinally both in a radial direction and in a direction tangential to the growth rings of the wood, the essential points of the gross structure can be studied. Such a block will show, on its cross-cut face, the annual rings, divided into heavy summer wood and light spring wood, the pith rays, and cross-sections of all the finer elements; the side on which the radial split was made, and also that on which the tangential split was made, will also show all these things, but from two different sides.

Now if it be imagined that one of these blocks has been cut so very small that an exceedingly thin shaving can be taken from its cross, radial, and tangential faces and put under the microscope and photographed (as actually can be done in a laboratory), the three photographs could be so arranged, by pasting them on a small block, as to show in detail the arrangement and interrelation of all the minute woody parts. This is exactly what has been done in preparing the blocks used in Figures 120 and 121 to illustrate the microscopic structure of soft and hard woods.

Microscopic structure of softwood: When one sees a thin slice of wood under a microscope, his first observation is that it is made up of a great number of cells, resembling in this respect the surface of a honey comb. Upon more careful examination, these cells are seen to differ from one another in a regular and orderly manner. If the first section seen is that of a softwood, it will be very much like the top of the block shown in Figure 120. The large cells, very like to, though less regular than, the cells of a honey comb, extend in orderly rows from the center to the outer edge of the wood, becoming smaller and more heavily walled and then suddenly larger and thin-walled at regular intervals. These cells are the cross-sections of the tracheids;

Cross-section.

and the regions where heavy walls prevail mark the slow summer growth, while the bands of thin-walled cells mark the rapid growth of spring. Narrow strands of fine, long cells, two of which appear as dark lines in the photograph, traverse the section in a direction parallel to the rows of fiber cells. These are the fine medullary rays. Here and there one will observe also a large, round space in the wood, surrounded by a ring of compressed, oval, thin-walled cells. These structures, one of which may be seen in the top of Figure 120, are the resin-ducts, wherein is stored the resin from which we derive turpentine and rosin after the trees have been bled.

If, next, we place a radial section of a softwood beneath our microscope, we will see something very much like the radial view in Figure 120. Running lengthwise of the section are long, narrow cells which

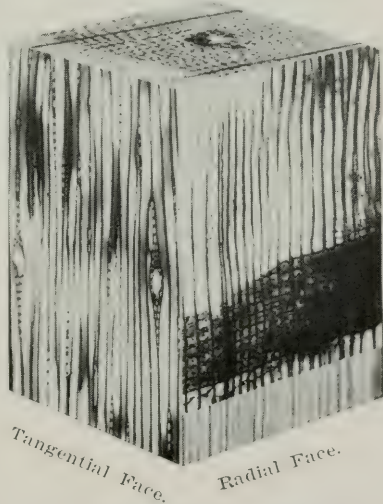


FIG. 120. Composite photomicrograph showing the microscopic structure of a softwood.

fit together at their ends by means of a long bevel. These cells we readily understand to be the tracheids which we have already seen in cross-section, and we can see that the straight grain of coniferous woods results from the straightness of these cells, while the strength of the wood results not only from the enormous number of these tiny fibers that is required to make even a small timber but also from the close-fitting and interjoining of the ends of the fibers. Here and there across the tracheids run broad plates of nearly rectangular cells, thinner-walled than the tracheids. These are the medullary rays, one of which appears as a dark band across the radial face of the figure. The round "frog-eye" marks which appear at frequent intervals in the walls of the tracheids are called "bordered pits," but their function is to serve as connections between the tracheids, through which water and food can pass easily.

Finally, we look at a tangential section and find it much like the tangential face of the block in Figure 120. The tracheids show as long, narrow cells joined by beveled ends, just as they did in the radial section; but the pith rays we now see as long, spindle-shaped rows of oval cells, scattered at intervals between the closely pressed tracheids. Here and there a broader and larger ray appears, with a space in its center about which are the oval cells characteristic of resin-ducts. With careful scrutiny under the high power of the microscope, we might make out also the structure of the bordered pits and see how the wonderful little door with which each of them is equipped can close the openings of the pits, now on one side and now on the other, and so regulate the flow of water and food from cell to cell.

Microscopic structure of a hardwood: There are a large number of differences between softwoods and hardwoods, as may readily be understood from Figure 121, which is a composite microphotograph of the wood of White Oak. On the top of the block is the cross-section. A little to the left of its union with the tangential face is a thin, dark line of heavily walled cells which mark the end of a year's growth, while just beyond this line may be seen the very large, round openings of the pores, or water-conducting vessels. Around and beyond them are the heavily and densely walled woody fibers. Parallel to the radial face, a broad medullary ray divides the section into halves, and finer rays can be seen at frequent intervals.

On the radial face of Figure 121, the pores appear as long, connected tubes filled with a kind of spongy growth (called tyloses by botanists), and the woody cells are seen to be of several kinds, some long and some short, some marked with pits and some with spirals and ladder-rungs,

some square at the ends, some beveled, and some jointed by interlocking forks—an array too formidable to be discussed outside of a text-book. Across these fibers extend the medullary rays, and their abundance and variety of shapes, when logs are quarter-sawed to show them to advantage in the lumber, give the “silver grain” effects so desirable in woods used for decorative purposes and for furniture.

Though the tangential face of our block does not show all the wood constituents, the medullary rays and the heavy, woody fibers can be seen plainly, while the appearance of the pores can be imagined as similar to that shown on the radial face.

Differences in hardwood structure: Although the soft woods are in general quite similar to each other, the hardwoods exhibit striking dissimilarities in their microscopic structure; and the differences, usually quite characteristic for each species of tree, determine the technical qualities possessed by the wood of every tree and, consequently, the uses to which it can be put.

One of the most obvious differences, and one that can be seen sometimes without the aid of a hand-lens, is the difference in the size and distribution of the pores. If they are exceptionally large and concentrated in a narrow ring in the spring growth of each year, the wood is described as ring-porous; but if they are smaller and scattered throughout the year's growth, the wood is said to be diffuse-porous. In general, ring-porous wood is apt to be weak, unless there is, as in the oaks, a strong development of heavily walled woody cells, while diffuse-porous wood is apt to be strong, unless the walls of the woody cells are thin and light.

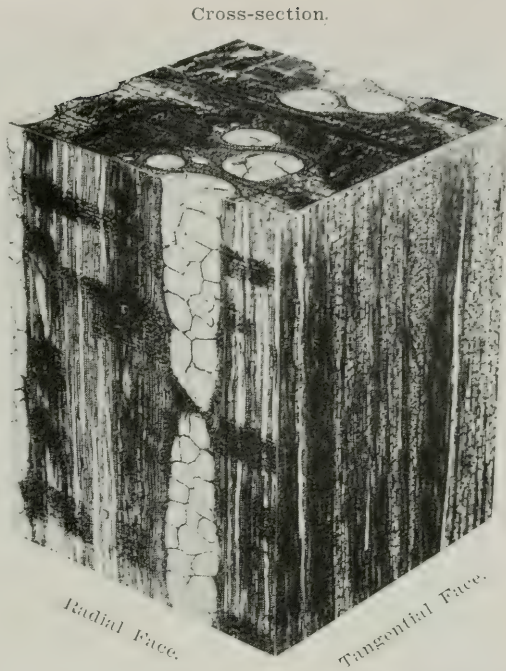


FIG. 121. Composite photomicrograph showing the microscopic structure of a hardwood.

Differences in the medullary rays are also of importance in determining the uses of woods. If the rays are narrow the wood usually has little decorative value; but those woods, such as oak, sycamore, and beech, which have wide rays are in great demand for cabinet making, furniture, and interior finishing, where the decorative effect of the rays can be displayed to good advantage.

By taking note of such differences as these, it is possible for the expert to determine exactly, from a very small block, the species of tree from which a wood is taken, and to suggest at the same time the uses to which it may be put advantageously. A complete discussion of these characters would be far too technical for the usual reader; but from what has already been said he will be enabled to see, in the photomicrographs which appear on the following pages, the most outstanding characteristics of the important woods taken from the trees native to Illinois.

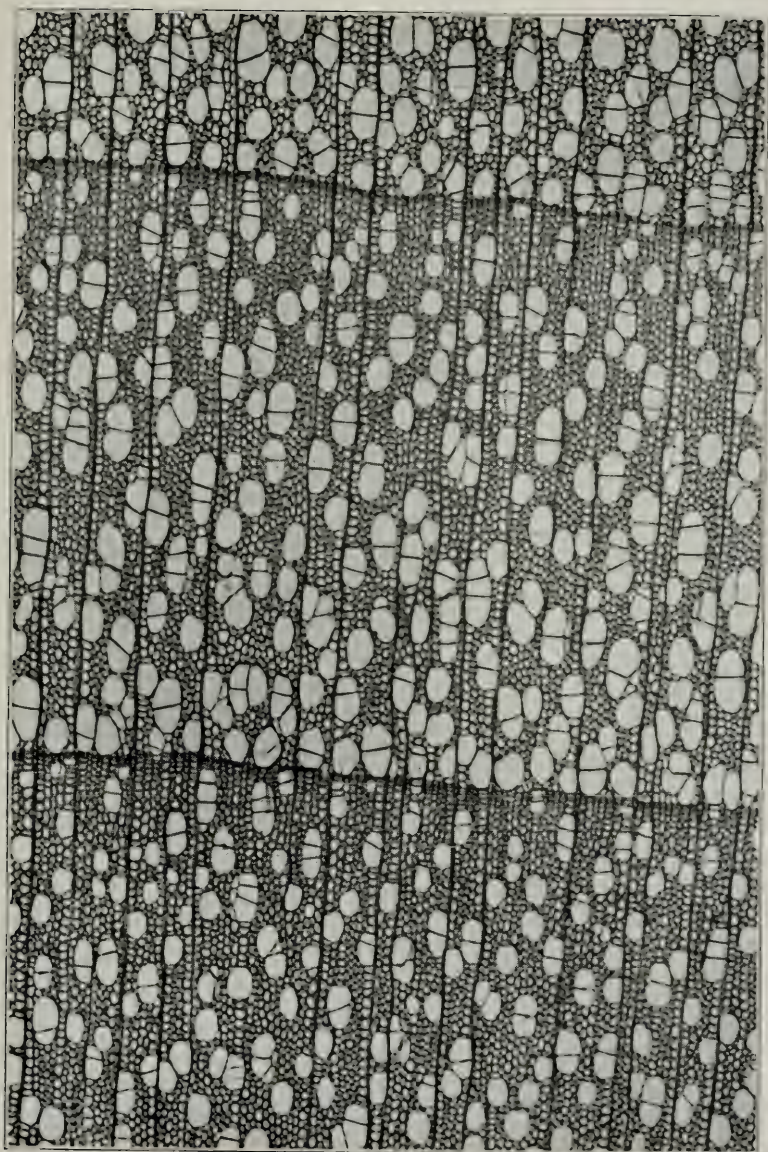


FIG. 122. Cross-section of the wood of the Aspen. A light-brown to silvery wood, with a fine texture and thin, inconspicuous rays. The pores are small and scattered through the year's growth.

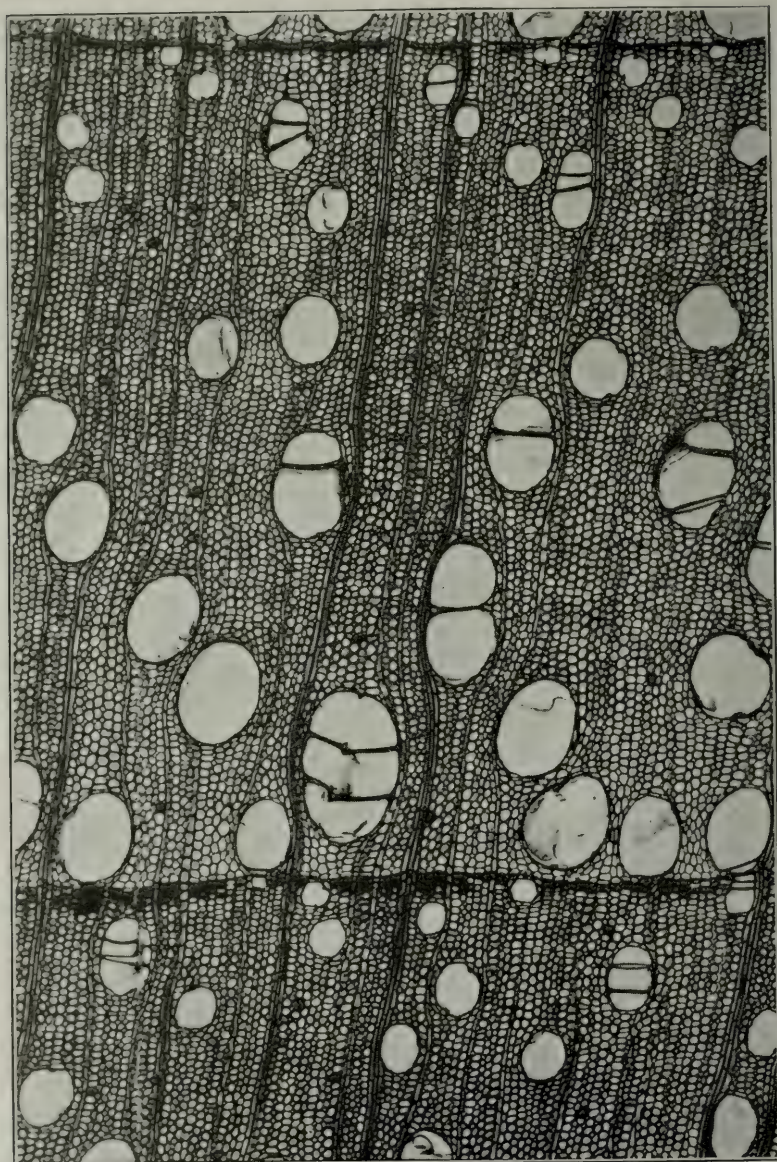


FIG. 123. Cross-section of Black Walnut. The pores are large and abundant in the spring wood, but become smaller and fewer in the later growth; and the rays are thin but numerous.

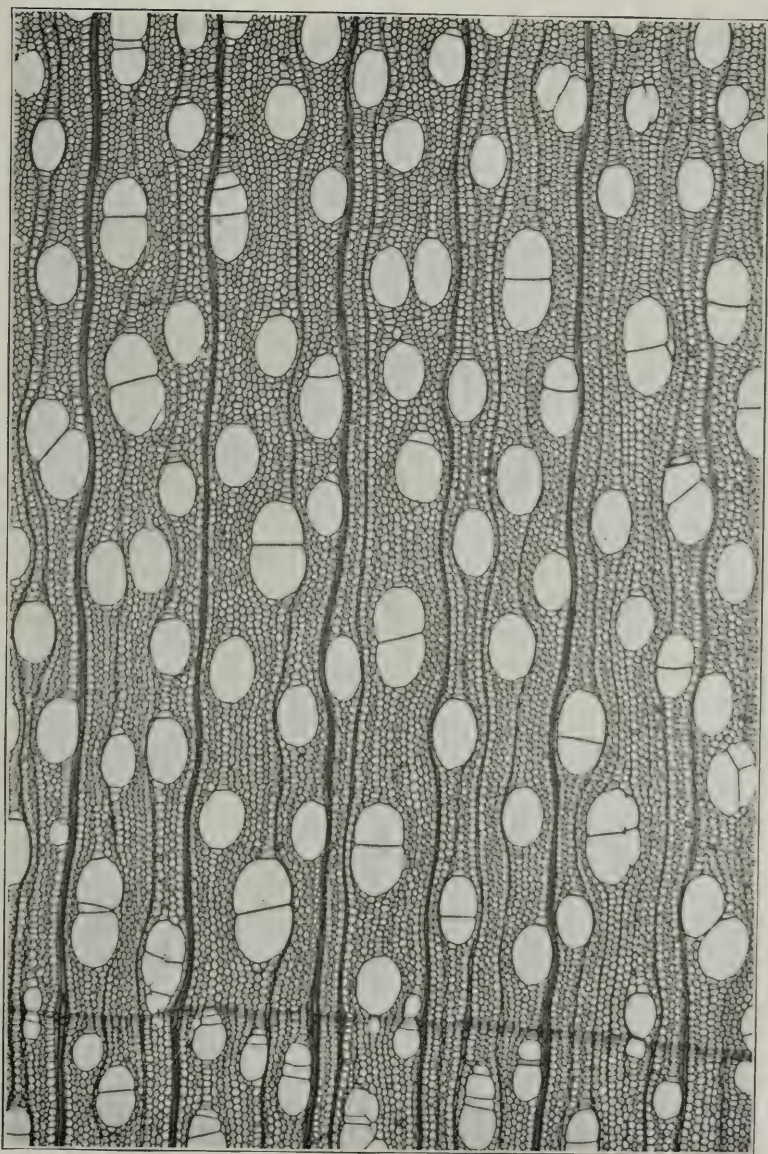


FIG. 124. Cross-section of the wood of the River Birch. The pores are small and uniformly scattered through the year's growth, the rays are straight and even but thin, and the wood fibers are thin walled. A light and soft but moderately strong wood.

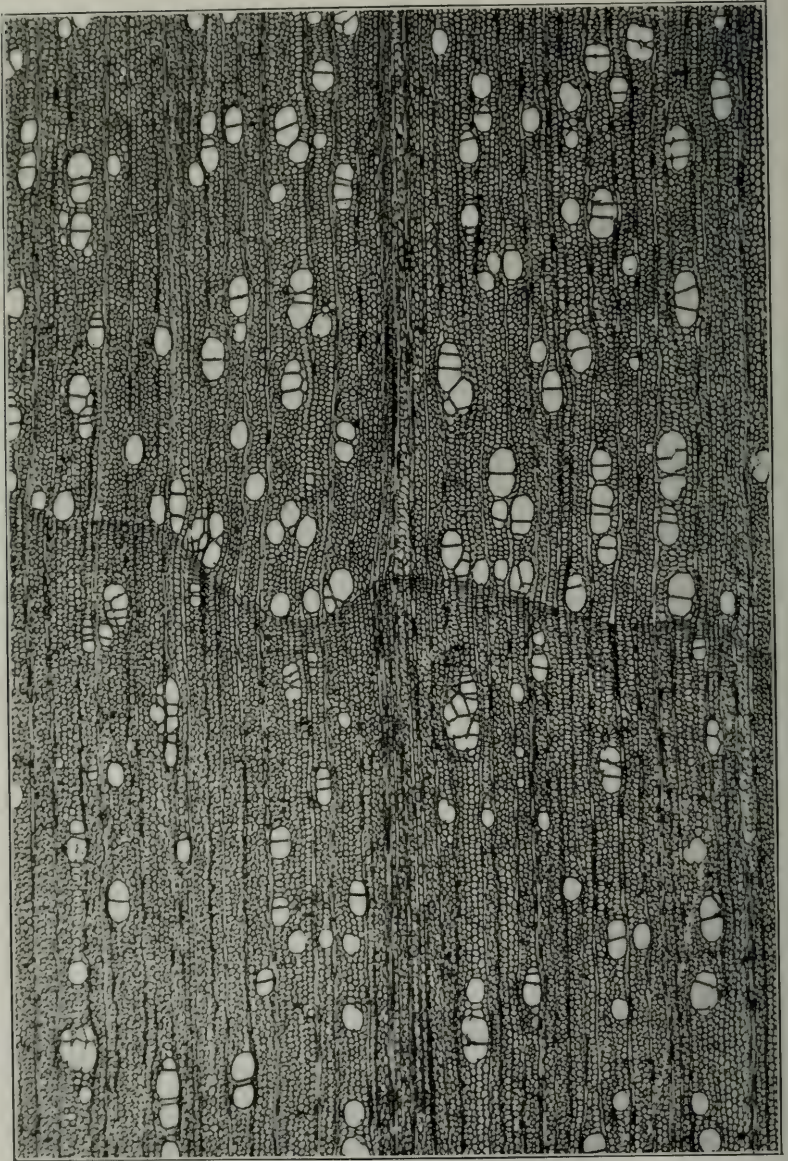


FIG. 125. Cross section of Blue Beech (Hornbeam). The pores are few, small, and scattered; the rays are very narrow and indistinct; the growth rings are uneven; and the woody fibers are small and heavy walled. A very heavy, hard, and tough wood.

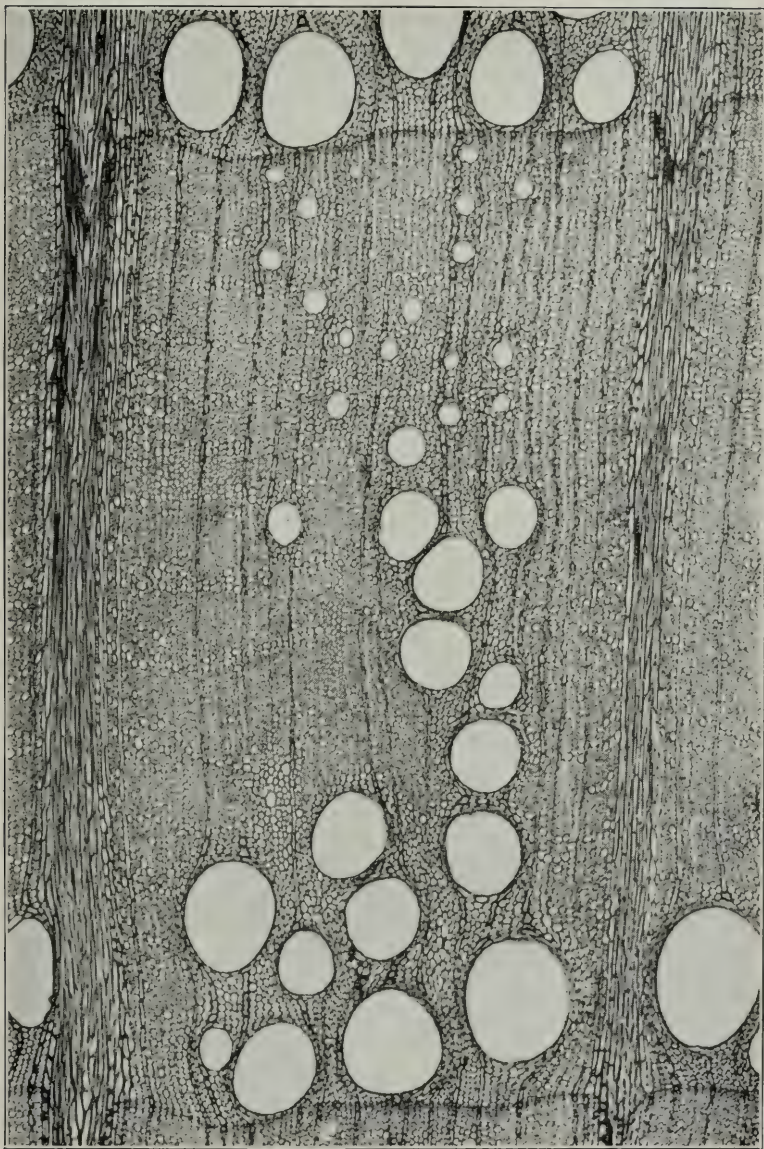


FIG. 126. Cross-section of Red Oak. The large pores are grouped conspicuously in the spring wood; there are both wide and distinct and fine, inconspicuous rays; and the woody cells have thick walls. The wood is hard and strong but coarse-grained.

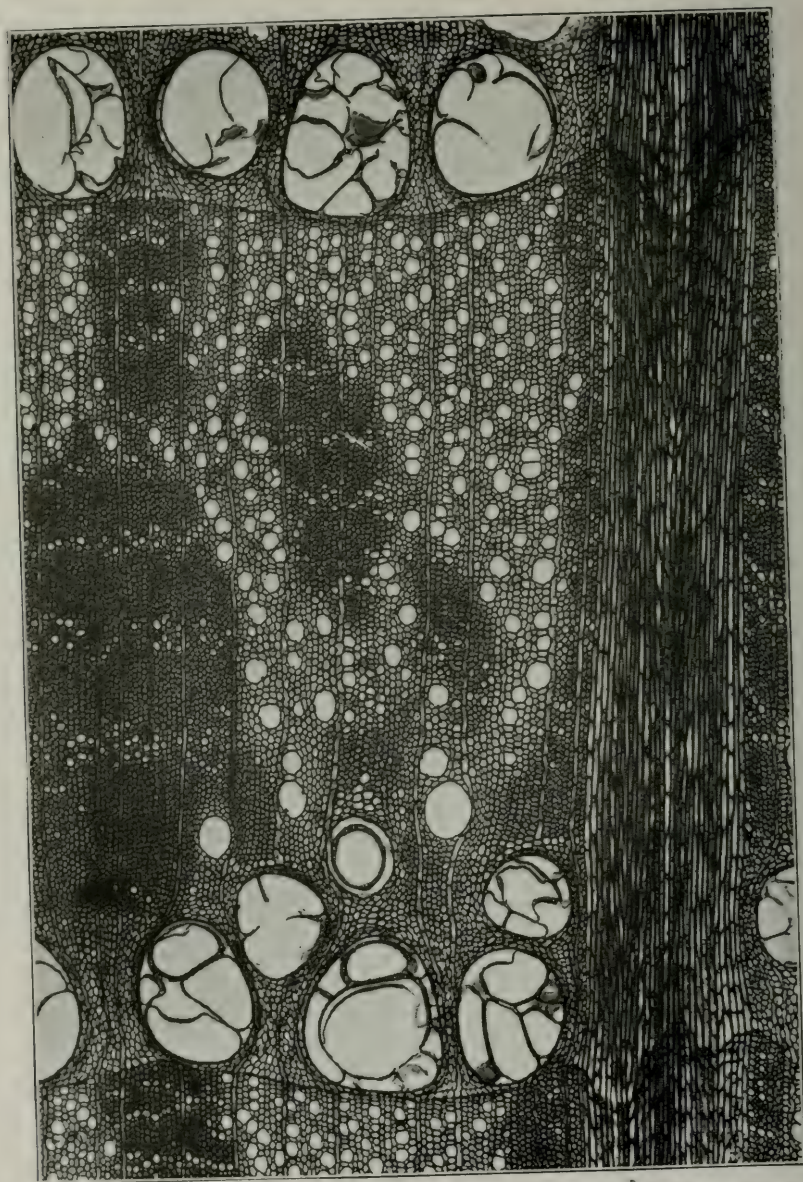


FIG. 127. Cross-section of White Oak. Ring-porous, with a few very large pores in the spring growth and many much smaller pores in the late growth; rays very broad and high; heavily walled woody cells very abundant. A strong, heavy, and hard wood which gives beautiful decorative effects.



FIG. 128. Cross-section of the wood of the Hackberry. Pores in the spring wood are large, those in the later growth rather large and grouped; the rays, though narrow, are very distinct; and the woody cells are very abundant. Though heavy, the coarse-grained wood is neither hard nor strong.

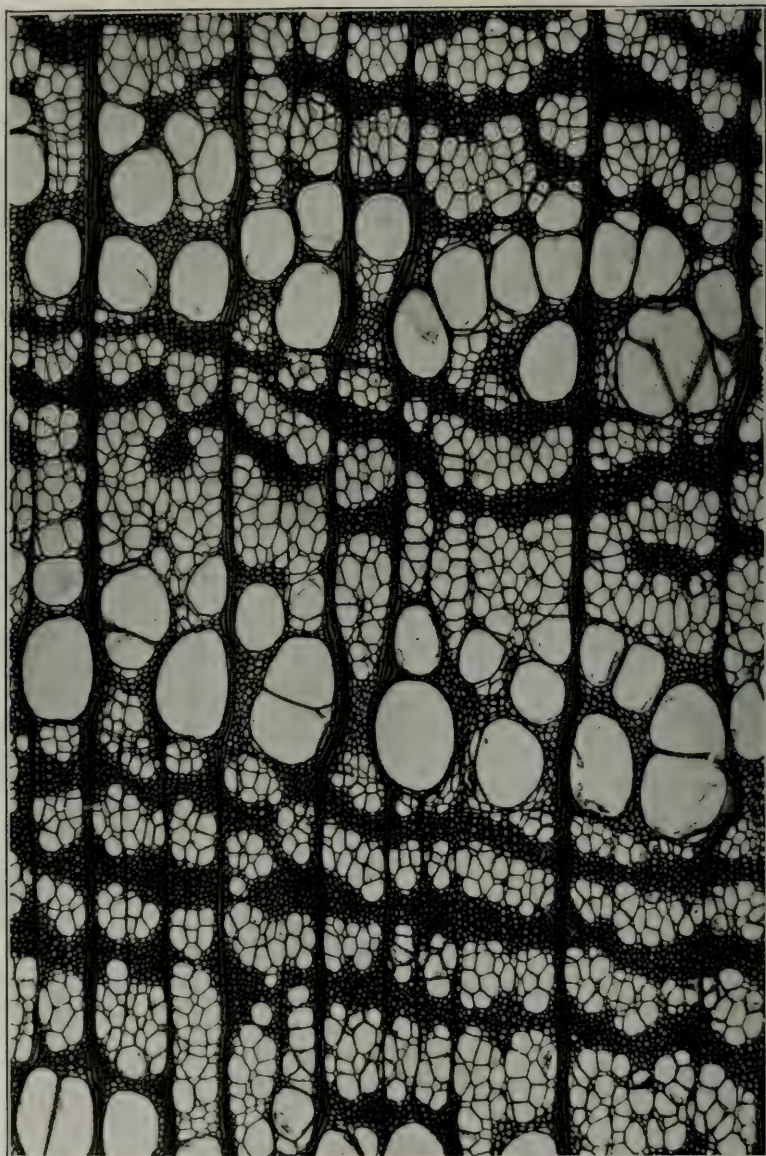


FIG. 129. Cross-section of Elm. The pores in the spring wood are very large while those in the later growth are smaller and are arranged in bands separated by bands of heavily walled woody cells. The rays are thin, though not indistinct. A moderately heavy, coarse-grained wood that is hard, strong, and tough.

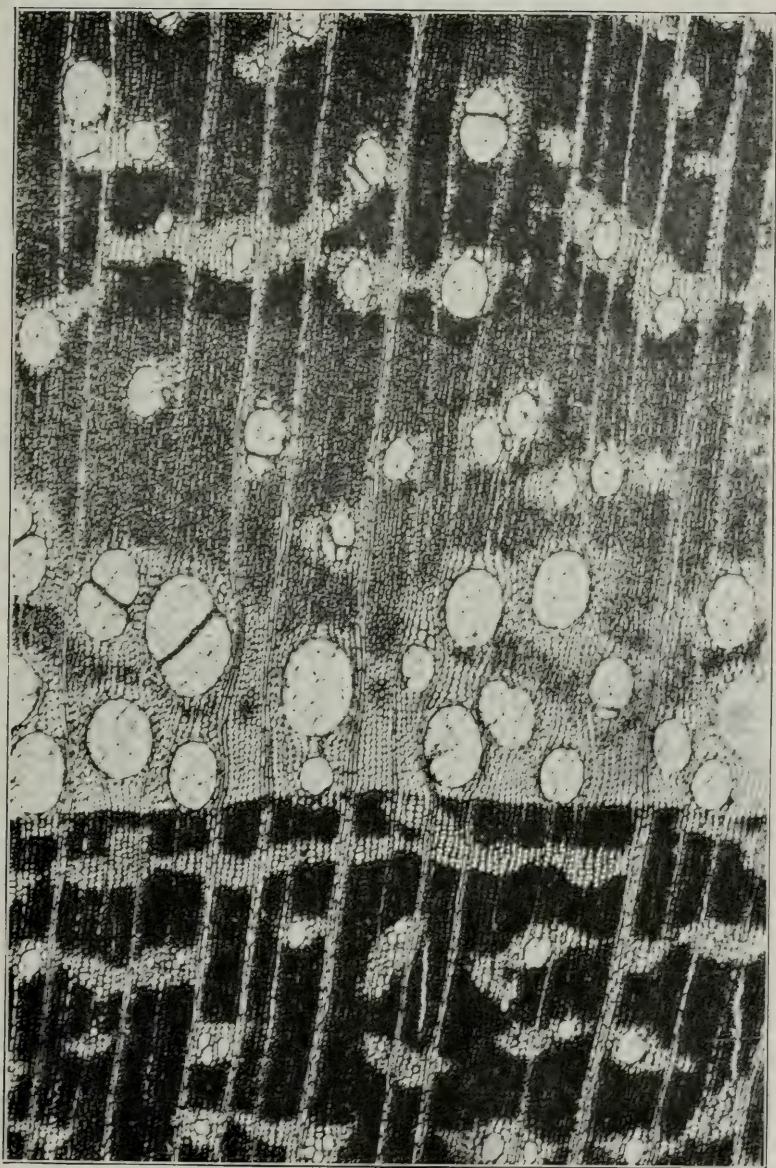


FIG. 130. Cross section of Osage Orange. The large pores are in a conspicuous zone in the spring wood; the numerous rays are narrow and fine; and the woody cells are extremely abundant. An exceedingly hard and durable wood that is both strong and flexible.

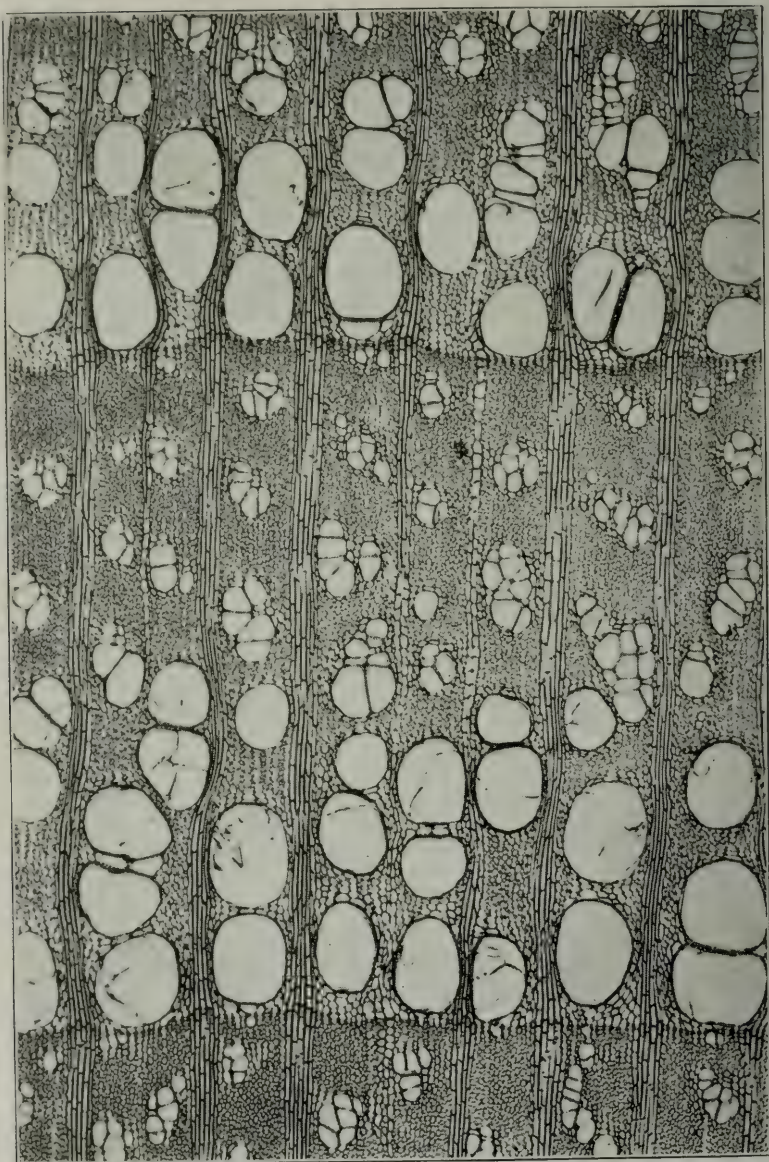


FIG. 131. Cross-section of Red Mulberry wood. The large pores are arranged in a wide zone in the early wood and the smaller pores stand in groups in the later wood; the rays are numerous and rather wide; and the woody cells, though abundant, are not heavy-walled. Though rather tough and coarse-grained, the wood is only moderately hard and strong.

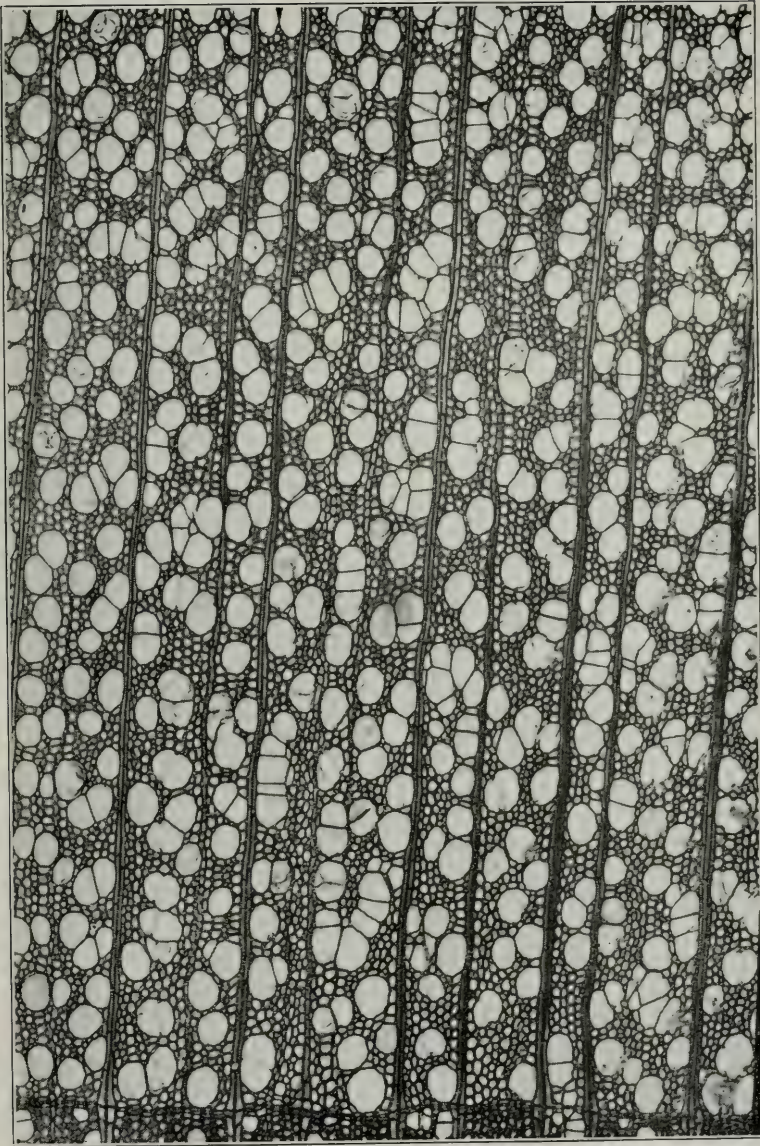


FIG. 132. Cross-section of Yellow Poplar. The pores are small, crowded, and through the year's growth; the rays are abundant and distinct, though narrow; and the woody fibers have thin, rounded walls. A fine-textured, easily worked, wood that is soft and brittle as well as light and weak.

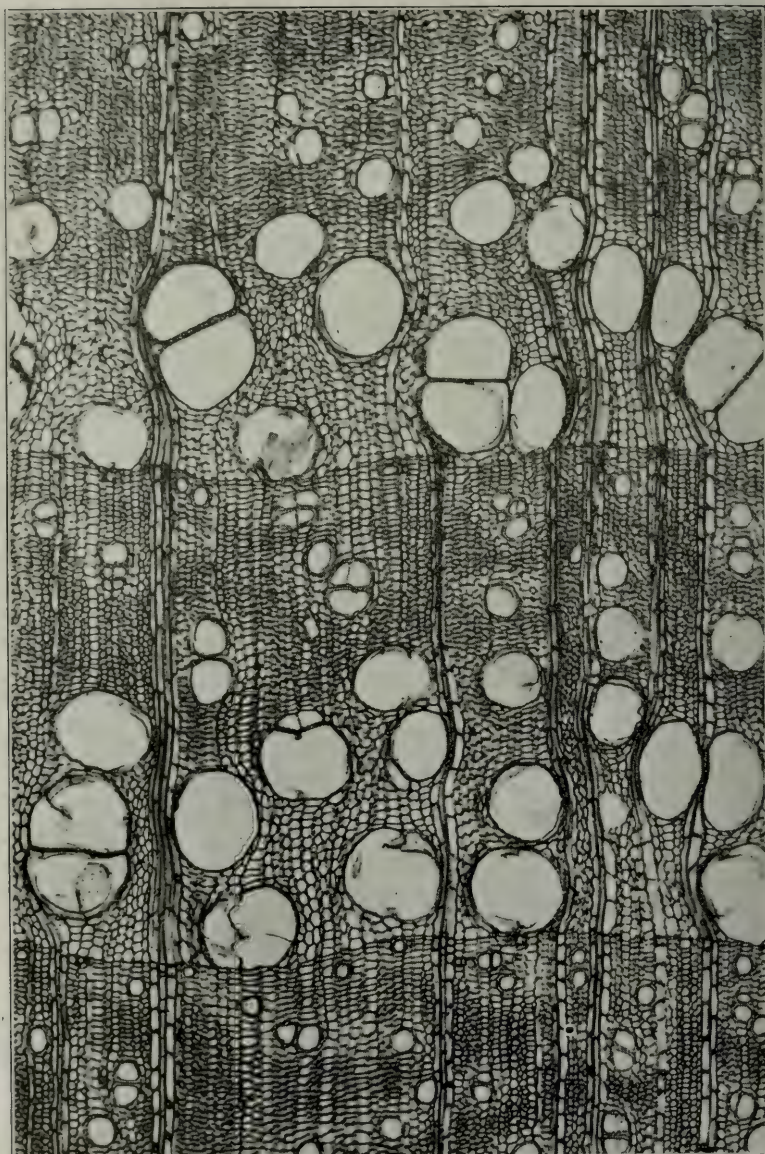


FIG. 133. Cross-section of *Sassafras*. The large pores in the spring wood are in a conspicuous, broad zone; the small pores in the later wood are in small, scattered groups; the rays are fine and narrow; and the woody cells are large and thin-walled. A light, softwood that, though durable, is coarse-grained, brittle, and weak.

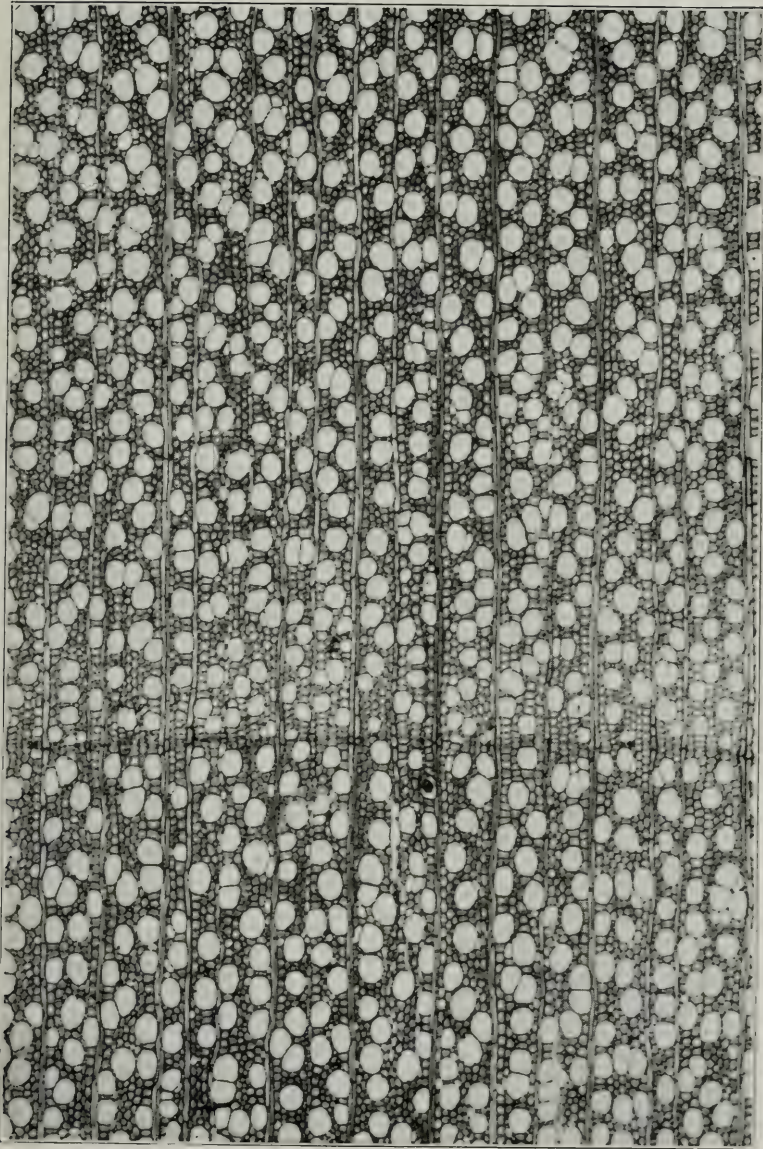


FIG. 134. Cross-section of the wood of the Sweet Gum. The small, crowded pores are uniformly scattered through the growth rings and are separated by numerous thick-walled woody cells. The rays are very fine and narrow, and the growth rings are indistinctly separated. A rather heavy, hard wood with crossed or interlocked grain, difficult to work but of a fine texture.

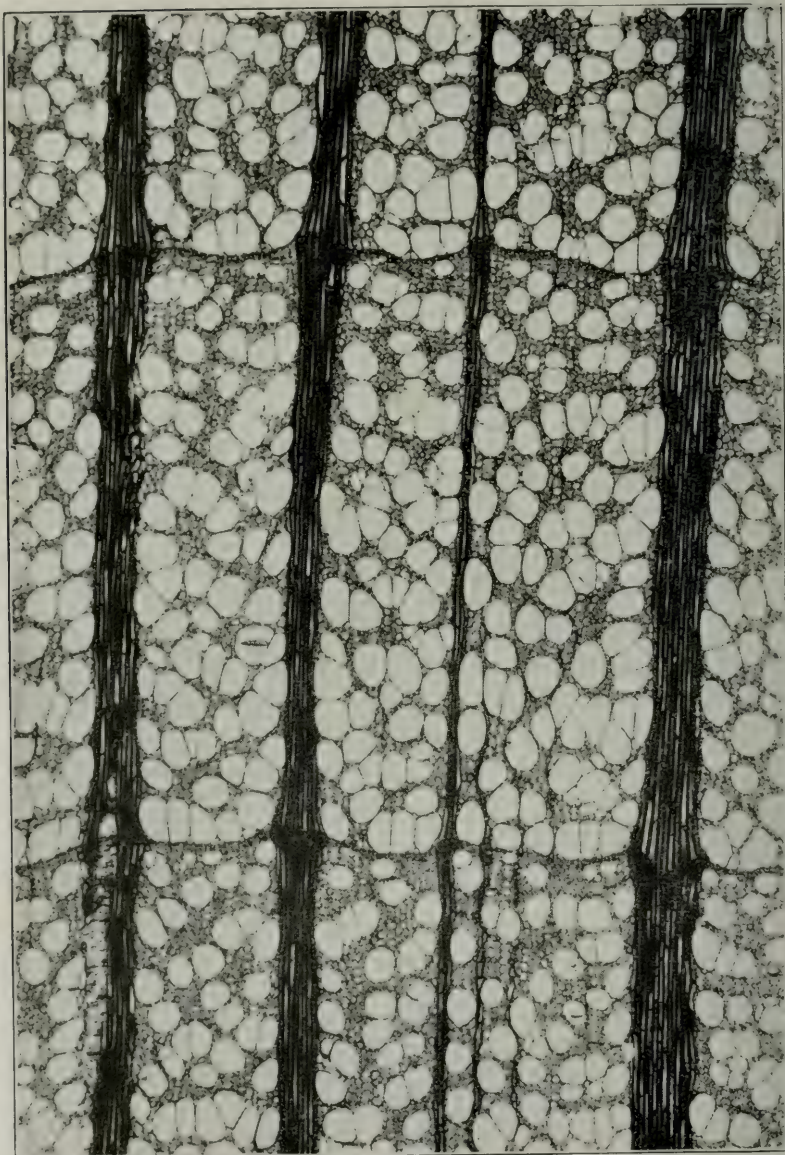


FIG. 135. Cross-section of Sycamore wood. The pores, somewhat more numerous in the early wood, are very small and crowded; the rays are all broad and high; and the woody cells are thick- and heavy-walled. A moderately hard, fairly heavy but not very strong wood, with a beautiful "silver grain."

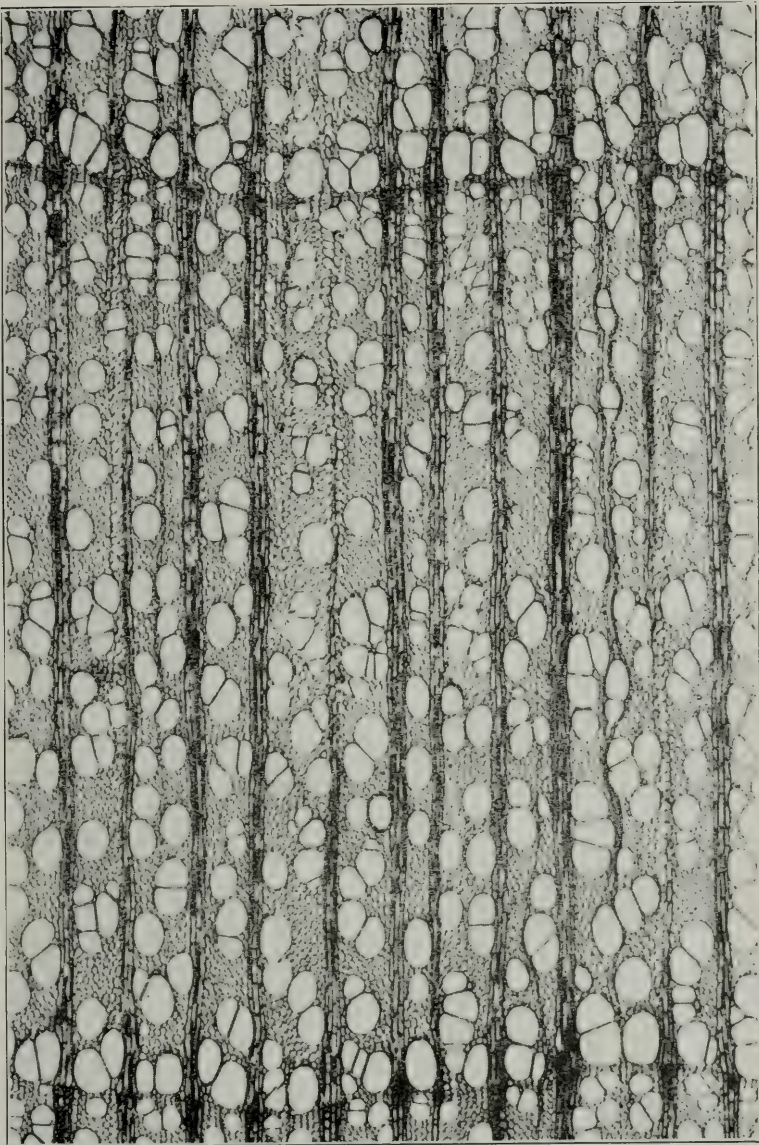


FIG. 136. Cross-section of Black Cherry wood. The numerous groups of small pores are well distributed through the growth rings; the rather thin-walled woody cells are abundant; and the rays are fine but conspicuous and gummy. A rather light and hard close-grained, strong wood with a satiny texture and a beautiful "silver grain."

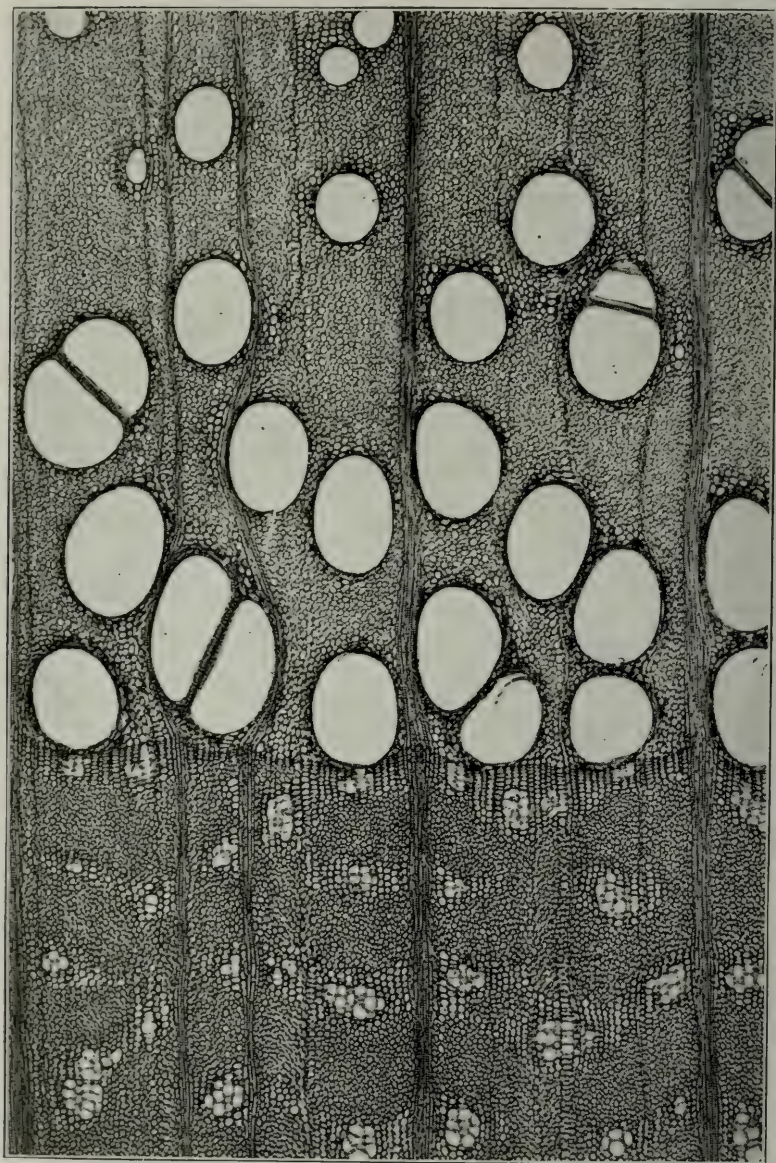


FIG. 137. Cross-section of the wood of the Honey Locust. The large pores in the early growth are arranged in a very broad band, and the small ones in the late wood are in small groups joined by bands of thin-walled woody cells. The bulk of the woody cells, are very small; and the rays are but conspicuous. A heavy, hard wood that is coarse-grained, and durable.

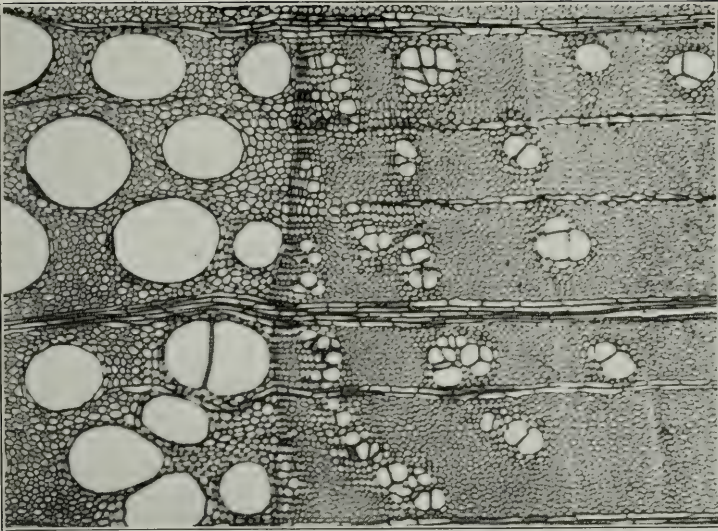


FIG. 138. Cross-section of the wood of the Kentucky Coffee Tree. Large pores of the early wood in a broad zone, small pores in the late wood grouped; woody cells thin-walled but very small and abundant; rays thin but distinct. Wood heavy, hard, strong, and coarse-textured.

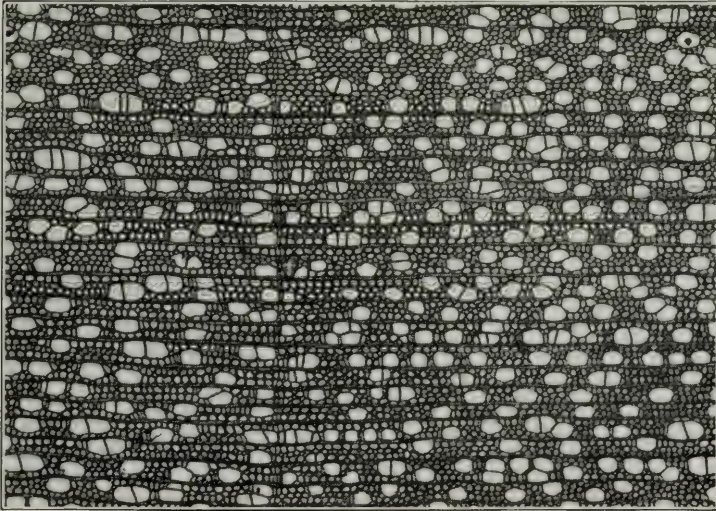


FIG. 139. Cross-section of the wood of the Ohio Buckeye. The pores very numerous, minute, and scattered; rays very fine and indistinct; woody cells abundant but large and thin-walled; growth rings indistinct. A fairly heavy wood that is strong but soft and coarse-grained.

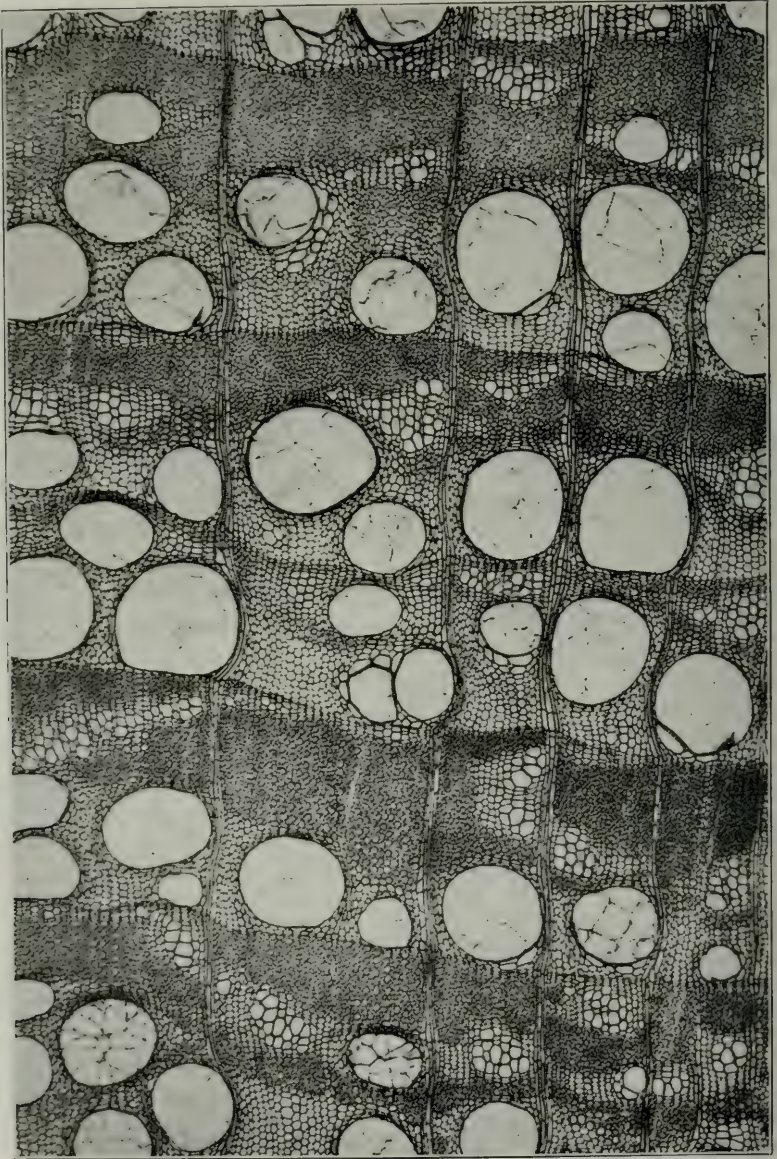


FIG. 140. Cross-section of the wood of the Black Locust. Large pores in a narrow band in the spring wood, the later growth of compact, heavy-walled wood cells; the rays fine or narrow and rather conspicuous. An extremely hard, heavy, strong wood that is close-grained and durable.

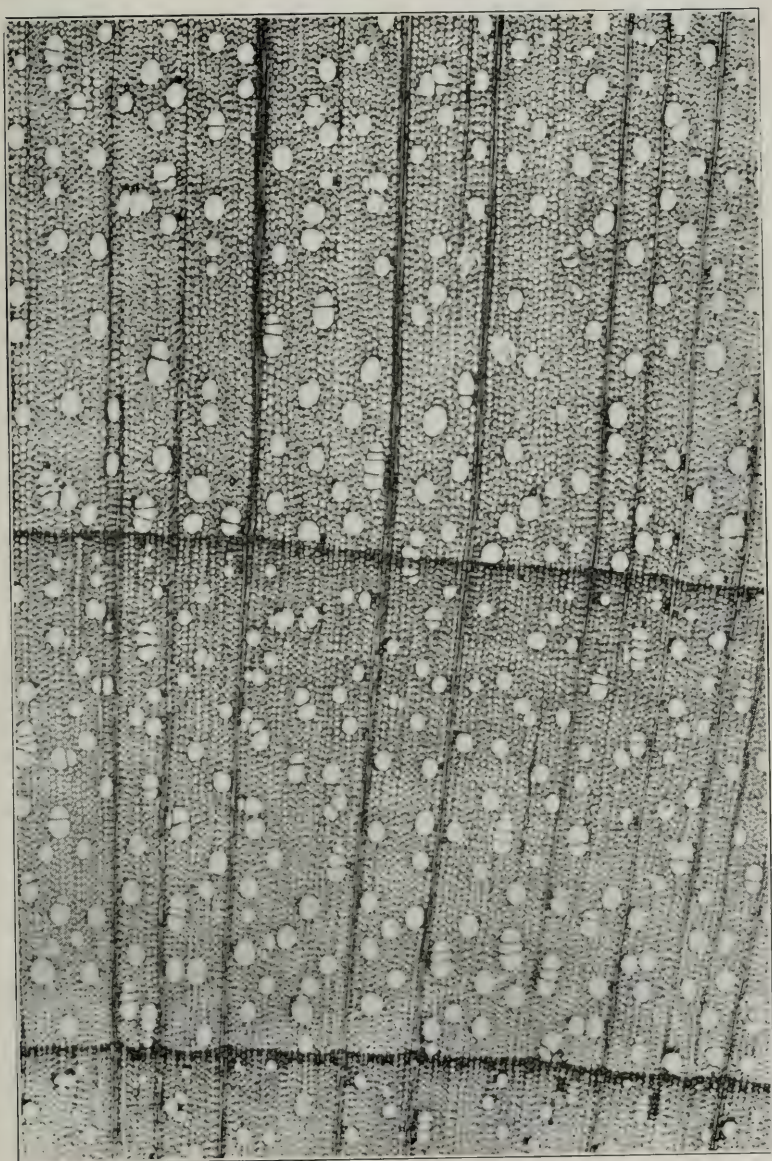


FIG. 141. Cross-section of the wood of the Sugar Maple. The small pores are numerous but not crowded; the woody cells are thin-walled but small and very numerous; and there are both fine and conspicuous rays. A very hard and heavy, strong wood that is both close-grained and tough.

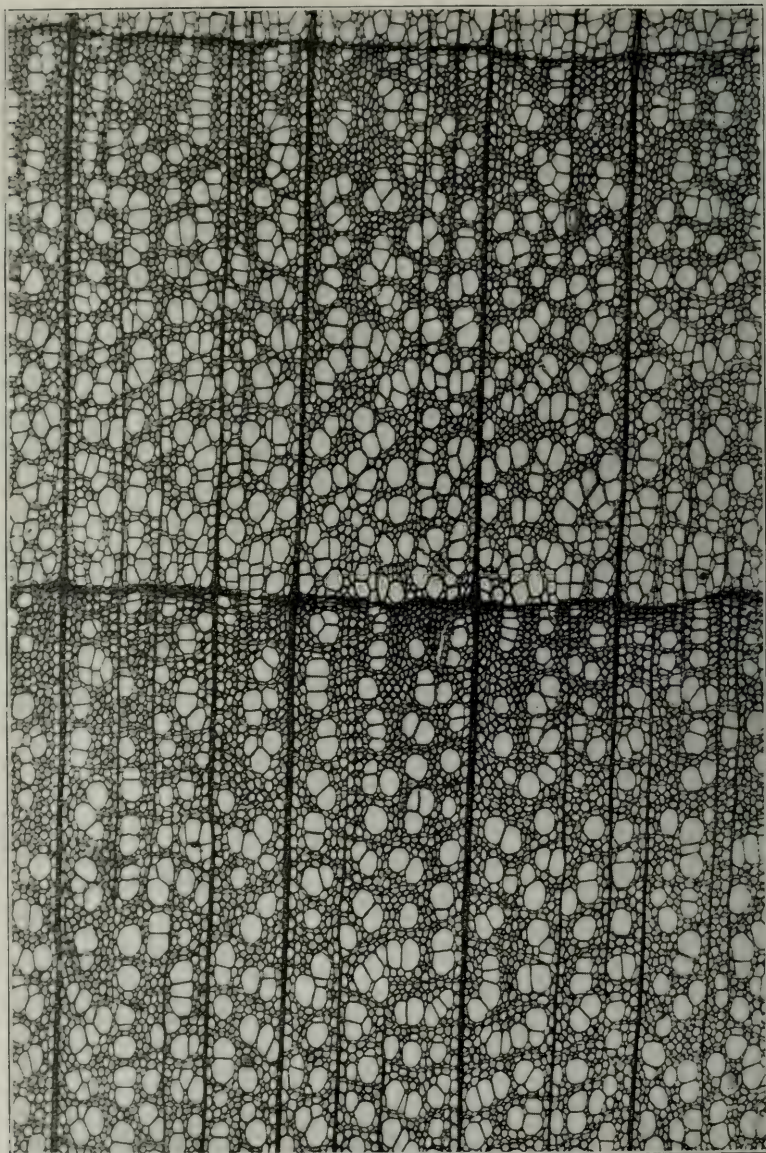


FIG. 142. Cross-section of Bass Wood. The pores are small, exceedingly numerous, and well distributed throughout the growth ring; the woody cells are rather large and thin-walled; and the rays are fine but often high. A compact but light wood that is both soft and strong.

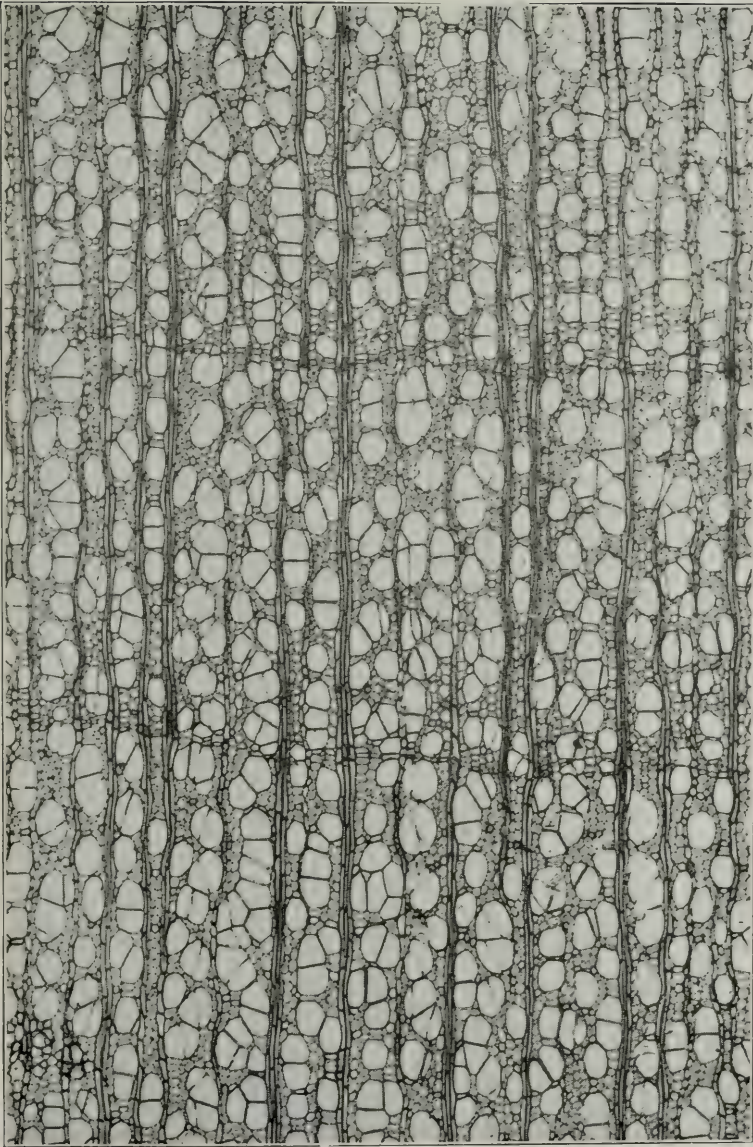


FIG. 143. Cross-section of the wood of the Tupelo. The pores are small, abundant, crowded, and evenly distributed throughout the growth rings; the rather large woody cells have thick walls and small cavities; and the rays are fine and narrow. A comparatively heavy wood that is strong and tough, though not very hard.

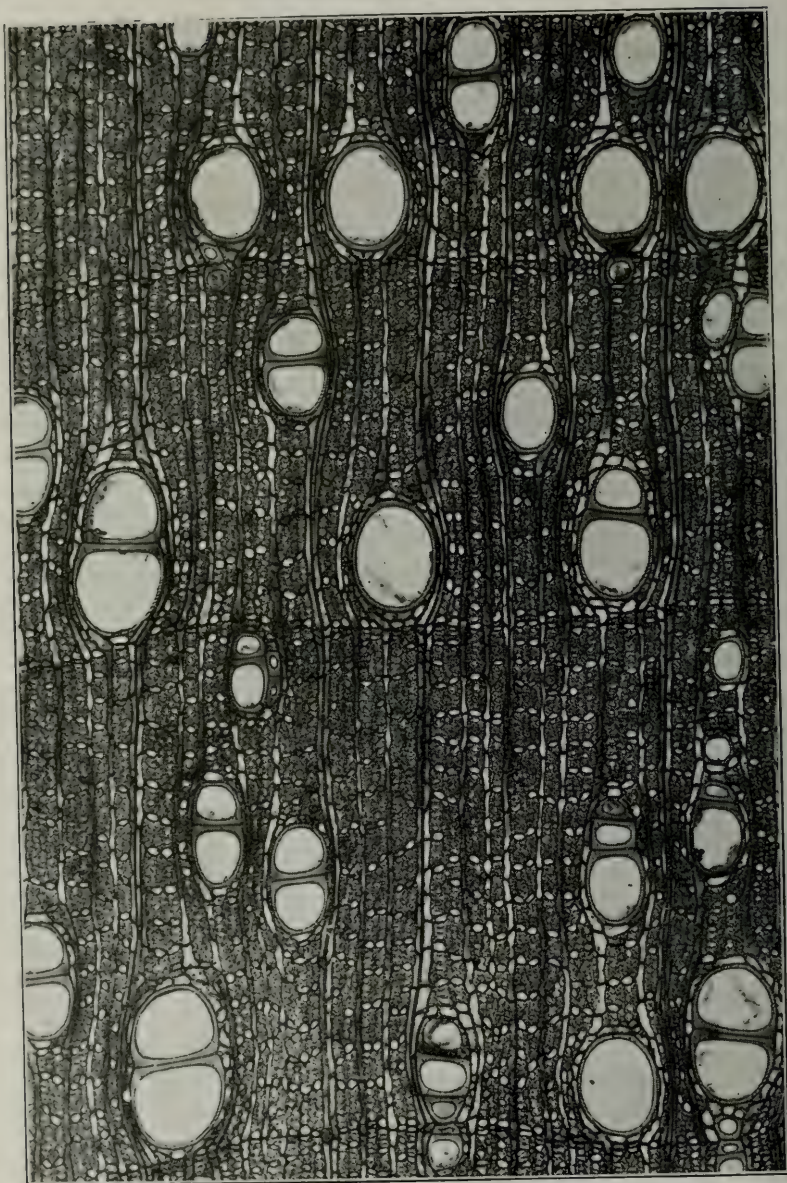


FIG. 144. Cross-section of the wood of the Persimmon. The pores in the spring wood large and in a narrow irregular zone, those in the late wood fewer but also large; the rays are fine, 1 or 2 cells wide; and the woody cells are small and abundant and very thick-walled. A wood so exceptionally heavy, hard, and strong that it is called "American ebony."

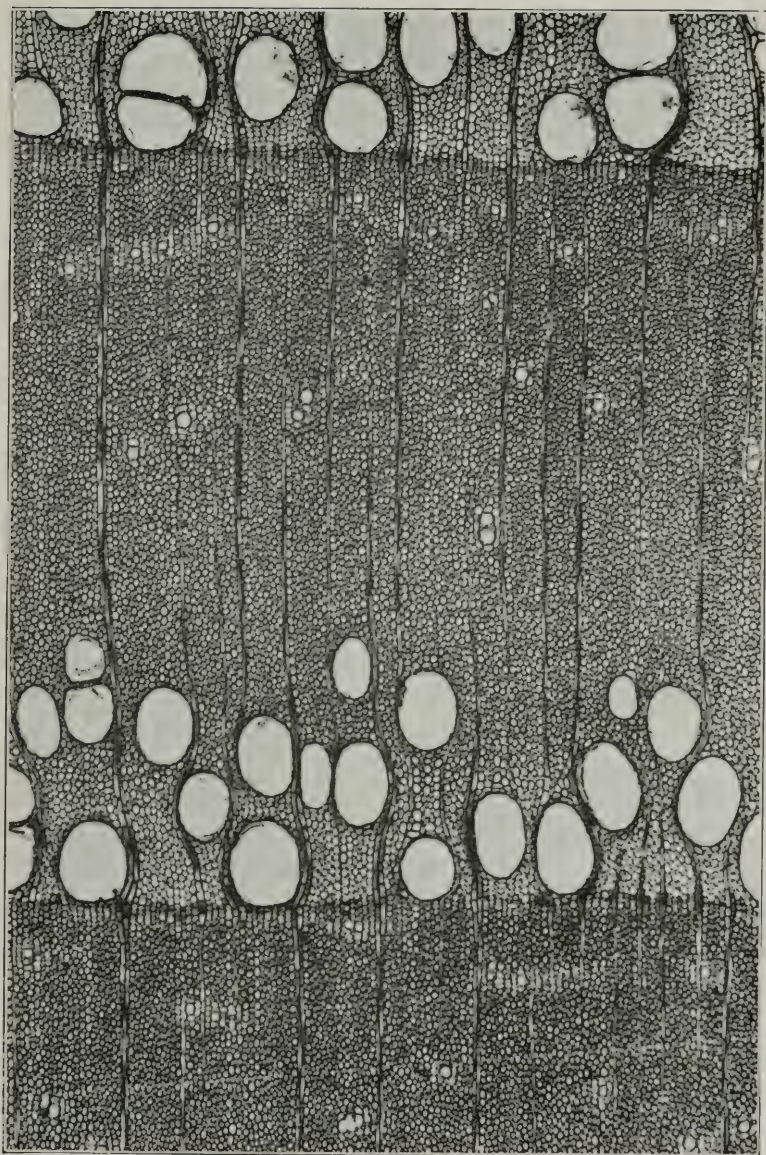


FIG. 145. Cross-section of the wood of the Black Ash. The pores in the early wood are large and arranged in a broad band, those in the late wood being few, small, and scattered; the woody cells are abundant and small but thin-walled; and the rays are fine though distinct. A rather soft and weak wood that is, nevertheless, heavy, tough, and durable.

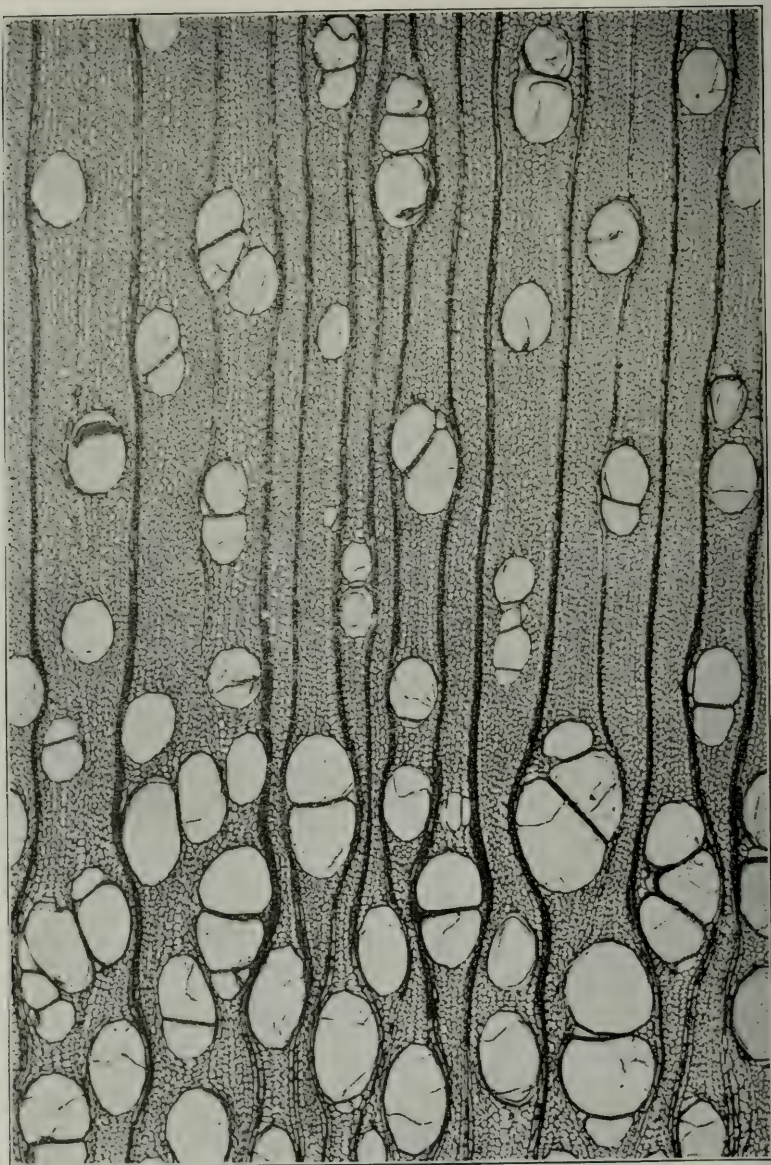


FIG. 146. Cross-section of *Catalpa* wood. The pores are large, abundant, and unevenly distributed; the woody cells are numerous, rather large, and thin-walled; and the rays are narrow and inconspicuous. A satiny-textured, very light and soft wood that is coarse-grained and durable.

FOREST INTEREST AND FOREST PRESERVATION

Interest in the trees of Illinois dates back to the closing years of the Eighteenth Century. In 1795, Andre Michaux, a distinguished French botanist, visited Illinois in search of plants which he intended to send home to enrich the gardens and pleasure grounds of his own country. Of the many interesting notes in his journal,¹ only two need be mentioned. Concerning the Hackberry, he said (December 7): "I have confirmed my opinion that the second bark of *Celtis occidentalis* (called in the Illinois country *Bois connu* and towards New Orleans *Bois inconnu*) is an excellent remedy for curing jaundice; a handful of the roots or leaves of *Smilax sarsaparilla* is added to it; it is used for about eight days as a decoction." And about the oaks he remarked (January 2, 1796): "Having nothing to do, I made ink with gall nuts which I gathered on the oaks in the vicinity of the spot where we camped. It was made in less than five minutes and will serve me as a sample."

Thomas Nuttall, a well known botanist from Massachusetts, made a journey down the Ohio and up the Mississippi to the "Arkansana Territory" in 1821 and made many notes regarding our trees. J. A. Lapham, a Milwaukee botanist, made journeys into Illinois as early as 1836, and subsequently, in 1856, he published a catalog of Illinois plants. At the State Fair of 1833, which was held in Chicago, Robert Kennicott, Emil Clausen, and some others exhibited a collection of plants, among which there were specimens of 70 species of trees. Dr. Frederick Brendel of Peoria suggested, in 1858, that the members of the Natural History Society should unite in an effort "to ascertain the northern and southern limits of trees," and in accordance with this suggestion Samuel Bartley, of Murphysboro, and C. Thomas, of Marion, made and reported some observations in their own counties. At the same time, Dr. Brendel read to the Natural History Society a paper on "Forests and Forest Trees," in which he enumerated the 6 conifers present in Illinois today and listed 60 deciduous trees, 40 of which were of large size.

In 1866, Dr. A. H. Worthen, the first State Geologist of Illinois, made many very detailed observations about trees, especially with reference to their relation to geology and soils, in St. Clair, Madison, Hancock, Hardin, Pulaski, Massac, and Pope counties. Twelve years later, Professor T. J. Burrill and Mr. W. C. Flagg prepared a list of Illinois plants,

¹ Proc. Am. Phil. Soc. 26:1-145.

in which the native stand of Chestnut in Pulaski County was mentioned for the first time. Another list of plants was prepared by William K. Higley and Charles S. Raddin and published in 1891 as a "Flora of Cook County, Illinois, and part of Lake County, Indiana."

During the three decades which have intervened, many special studies have been made of the plants and trees of Illinois, chiefly from the standpoint of ecology. Most of these have been referred to in the discussion of the individual trees.

Interest in trees, as a matter of tree planting and forestry, received a decided stimulus between 1870 and 1880, and many of the tree plantations now growing in Illinois date back to that period. Arbor day was inaugurated by Governor Morton of Nebraska in 1874, and the American Forestry Association was organized in Chicago in January, 1875. John A. Warder, of Ohio, in speaking before the Illinois Horticultural Society in 1878 referred to the fact that the railroads of the country were using 40 million ties annually (they now use 125 million) and that measures should be taken to provide for a future supply; and in 1882, Franklin B. Hough, who held a position corresponding to the present Chief Forester of the United States, also spoke of the tie situation, estimating the number used at that date as 56,571,428, for which at least 565,714 acres of land had to be cut over annually, supposing a production of 100 ties per acre and a durability of seven years for each tie.

At about this time, the University of Illinois secured an appropriation of money from the State Legislature, by means of which a Forest Tree Plantation was established. Planting was begun in the spring of 1871, and 30 species of trees were set out, 4 of them being European, 3 from other states, and 23 native forest trees of Illinois. The larger part of this plantation still remains, as a demonstration that Black Walnut, Green Ash, European Larch, Catalpa, Soft Maple, and Bass Wood can make good growths on black clay-loam soils. It has shown, too, that White Pine, White and Burr oaks, and Hickory grow very slowly on such soils, and that, on the whole, forests should be grown on cheaper lands.

One of the largest plantations in the State was established between 1871 and 1874 by Mr. J. B. White in Christian County. It consisted of a strip of trees 100 yards wide placed along the north, west, and south sides of a quarter section and a block of 13 acres on the east side of the quarter. The species planted were Ash, Osage Orange, and Catalpa, with a small proportion of Larch, Norway Spruce, Austrian and Scotch pines, Sugar and Silver maples, Honey Locust, Burr Oak, and Hickory. Mr. A. N. Abbott, of Morrison, who has planted 50,000 trees with his own

hands, has demonstrated that planting will stop "blow sand," the Cottonwood being perhaps the best tree for that purpose. The Chicago Burlington and Quincy railway has also planted thousands of Catalpa trees along its right-of-way, some of which are large enough for fence posts; but it is a question if they can be brought to tie size within a reasonable length of time without underplanting. Due to the extensive sale of catalpa some years ago by unscrupulous salesmen who recommended it for all purposes and on land not suited for growing it, to the planting of Black Locust on sand where it has made a complete failure because it was attacked by the locust borer, and to the high prices charged for nursery stock, our area of forest plantations in Illinois is about at a stand-still. Enough information is now in possession of our State and Extension Foresters, however, to enable them to give intelligent advice on the usefulness of most species and so at least help planters not to make costly mistakes. With nursery stock obtainable at reasonable prices, another stimulation may come soon in forest and windbreak planting, which will place them on a sane and permanent basis.

A further indication of the present interest in trees is found in the fact that there are now two splendid arboretums in Illinois. The Morton Arboretum, located near Lisle, has been established only recently, while "Bird Haven," the personal property of Robert Ridgway, has been under development for many years.

The Morton Arboretum: The Morton Arboretum at Lisle, Dupage County, Illinois, was founded in 1921 by Joy Morton. Its purposes and aims are thus expressed in the declaration of trust establishing it: "creating a foundation to be known as the Morton Arboretum, for practical, scientific research work in horticulture and agriculture, particularly in the growth and culture of trees, shrubs and vines by means of a great outdoor museum arranged for the convenient study of every species, variety and hybrid of the woody plants of the world able to endure the climate of Illinois, such museum to be equipped with an herbarium, a reference library, and laboratories for the study of trees and other plants, with reference to their characters, relationships, economic value, geographical distribution and their improvement by selection and hybridization; and for the publication of the results obtained in these laboratories by the officials and students of the arboretum, in order to increase the general knowledge and love of trees and shrubs and bring about an increase and improvement in their growth and culture."

The four hundred acre tract selected for the Arboretum is situated one mile north of Lisle and about twenty-five miles west of Chicago, and

is easily reached by motor cars over Ogden Avenue or Roosevelt Road or by train to Lisle on the Chicago Burlington and Quincy railway. Over 4,000 different species of woody plants are already growing at the Arboretum, and its usefulness is being increased by the issuing of bulletins of popular information.

Bird Haven: At Olney, in Richland County, not far from the celebrated lower Wabash Valley region of Indiana and Illinois, stands Robert Ridgway's Bird Haven. It is remarkable because it has been built up by a man of limited resources who has been occupied in other scientific pursuits. Much of the planting and transplanting has been done with his own hands or under his personal supervision. Mr. Ridgway has also in the town of Olney his home place, called Larchmound, which covers about five acres, where many trees and shrubs, strangers to Richland County and even to America, are growing around the house and in the gardens. On these grounds he also maintains a small nursery, where the less hardy plants are carefully nurtured before they are transferred to the woods at Bird Haven. Mr. Ridgway tells in his own words the objects and accomplishments of Bird Haven:

"Bird Haven is situated two and one-fourth miles north of Olney, Richland County, Illinois, on the east side of the Macksburg road. Its area is about 18 acres. It is bordered along the south side by a 65 acre tract of heavily culled woodland; on the north and east sides by open fields. The higher grounds, which occupy more than half of the total area, are elevated about 36 feet above low water level in the creek, the east fork of Fox River, which intersects the northeastern portion. This stream is constantly fed by springs which emerge beneath the surface of the water along the south side, a depth of not less than three feet being thus maintained during the driest seasons. The steeper hillsides face the north, those facing the west and east having longer and more gentle slopes. A secondary stream, becoming dry in summer, intersects the western portion, entering the main stream just outside the northwestern corner of the property. The higher grounds are mostly wooded and there are many trees in the bottoms of the smaller stream; but the bottoms between the hills and the main stream, comprising an area of about three acres, are completely cleared, except along the banks of the creek and along the eastern border.

"Bird Haven represents a modest effort at conservation of wild life on a small area. Its establishment was prompted by a sad realization that our beautiful and interesting forests are disappearing so rapidly that the original virgin forest is now a memory only to the oldest inhabitant, while

the change in the woods that are left is so great that a real virgin forest is almost if not quite beyond the conception of the present generation.

"The ground selected is not the best for the purpose that could be found but was the only one available under the purchaser's limitations. The timber, which occupies about three-fourths of the area, is second growth, the land having been under cultivation as late as 1812. The soil on the hills is very poor, owing to exhaustion and washing during the period of cultivation; and the bottomlands are subject to frequent inundations. These disadvantages, however, are off-set, in a measure, by the very unusual richness or variety in the tree growth, and convenient access from the town.

"As previously stated, about one-fourth of the surface of Bird Haven is treeless. There are, therefore, approximately 13 acres that are more or less thickly wooded. On these few acres there are growing naturally, 73 species and varieties of trees, three of which, however, are naturalized extralimital species, leaving a total of 70 indigenous species and varieties. This is a larger number of dicotyledonous (broad leaved) trees than are native to the entire Pacific coast, from southern California to Alaska, inclusive; while of the oaks alone (10 species) there are only two less than the number of species of oaks growing naturally on the 59,424 square miles of the six New England States.

"A few old white oak stumps are all that remain of the original growth. As to the character of this growth, I have been so fortunate as to learn much from the man who sawed the timber—Mr. John Fahs, now of Los Angeles, California. According to him on the hills it consisted principally of splendid white oaks and sugar maples, though many other species were mingled with them. On the bottomland other oaks, chiefly the burr oak, swamp white oak, pin oak, bottom red oak (*Q. Schneekii*) sweet gum, red maple, sugar maple, American elm, and other moisture-loving species predominated.

"Although conservation of the wild life was the chief motive in establishing Bird Haven, I had other objects in view. It had long been my desire to experiment with the planting of numerous kinds of woody plants that had never been grown in this part of the country, in order to test their adaptability to the climate and other local conditions; and when a "census" had been made of the ligneous species that were growing on the selected tract the idea naturally suggested itself of adding other Illinois species until the ligneous flora of the State became completely represented. Thus my plan included (1) the conservation of the original flora, (2) the development from the nucleus already there of a state

arboretum and (3) the experimental planting of previously untested extralimital species, both American and exotic. In accordance with this plan there have been added to the 73 kinds of trees growing there naturally 89 species of Illinois trees; to the 22 shrubs, 51 species; and to the 17 woody climbers 14 species, making a total of 162 species and varieties of Illinois trees, 73 Illinois shrubs, and 31 Illinois woody climbers—a total of 266 species and varieties of woody plants native to or naturalized in Illinois—that are now established on Bird Haven.

"Of species extralimital to Illinois but indigenous to other parts of the United States there have been planted 38 species of trees, 13 shrubs, and 7 woody climbers. These include the more interesting or ornamental kinds, among which may be mentioned the Magnolias, of which 7 of the 8 North American species are represented, the only one wanting being the rare and local *Magnolia pyramidata*.

"Of exotic species (chiefly from eastern Asia), there have been planted 25 species of trees, 28 shrubs and 14 woody climbers. Thus there are now growing on Bird Haven 225 species and varieties of trees, 114 shrubs and 52 woody climbers, a total of 391 ligneous plants."

FOREST PRESERVES FOR RECREATION

One of the greatest purposes to which a forest can be put is that of furnishing recreation; and for this purpose alone, without the need of any additional weight of practical and sentimental reasons, steps should be taken to preserve the few remaining forests of our State. The rest, the health, and the contact with nature that could be gained every year by an ever-increasing number of people would be an "annual crop" fully as valuable as any amount of timber that could be harvested.

Some attempts have been made already to preserve the fast-vanishing woodlands, and there is among our State's laws a Forest Preserve Act which enables the counties to set aside and maintain valuable tracts of land for the growing of trees. Cook County was the first to take advantage of the Forest Preserve Act, and its example has been followed by DuPage and Winnebago counties, while movements are being inaugurated in other counties with the same end in view.

Cook County Forest Preserves: The Forest Preserves of Cook County add to the city of Chicago an outer belt or system of parks in which recreation is the outstanding feature. The strength of man's elemental craving for the great open spaces is shown by the fact that in 1925 over 10,000,000 people visited these preserves, which now include a total

of 30,142 acres. All of this land has been acquired since 1913, and the ultimate goal is about 35,000 acres. Not all of this acreage is wooded. Some is given over to golf courses, baseball diamonds, tennis courts, and parking places, and there are natural open spaces in the woods. The Forest Preserve District has also acquired title to more than 1,000 acres of the Skokie Marsh, and this entire moorland, which amounts to over 2,000 acres, may in time be preserved from drainage projects and kept in its primitive condition. The average cost of land for the preserves has been \$500 an acre, a very reasonable figure when the values of property in many surrounding districts are considered; and many of the tracts have increased greatly in value since they were acquired.

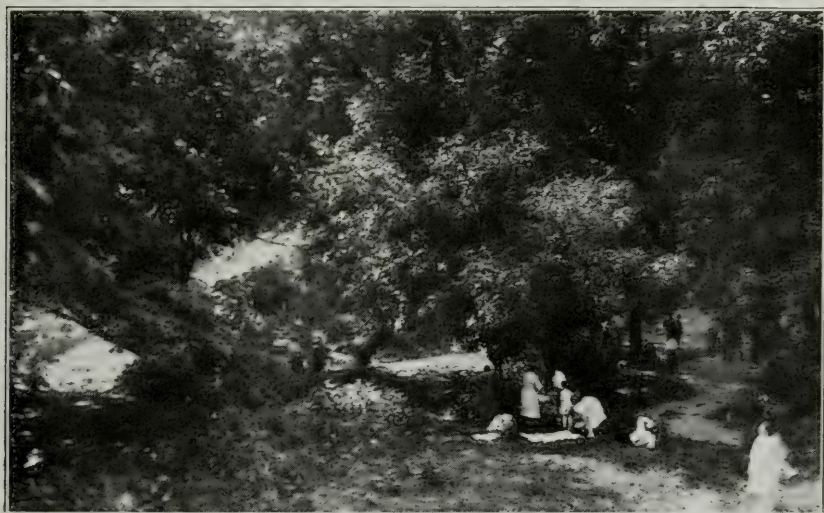


FIG. 147. Forest recreation: A picnic in a Cook County Forest Preserve.

The activities of the preserves can best be learned by a trip through them, which will require much longer than a day, although a great deal of ground can be covered in that time on the excellent roads which stretch from one preserve to another and through the preserves themselves. Good roads are a first essential, but there must also be means for handling the public efficiently and for increasing the recreational facilities, among which are the deepening of ponds and streams, the construction of shelters and comfort stations, building of cabins and fire places, drilling of deep wells, erection of tables for campers and picnic parties, providing parking places for automobiles, looking after concessions of various sorts, etc. One rather original feature is the construction of dams on the Des Plaines

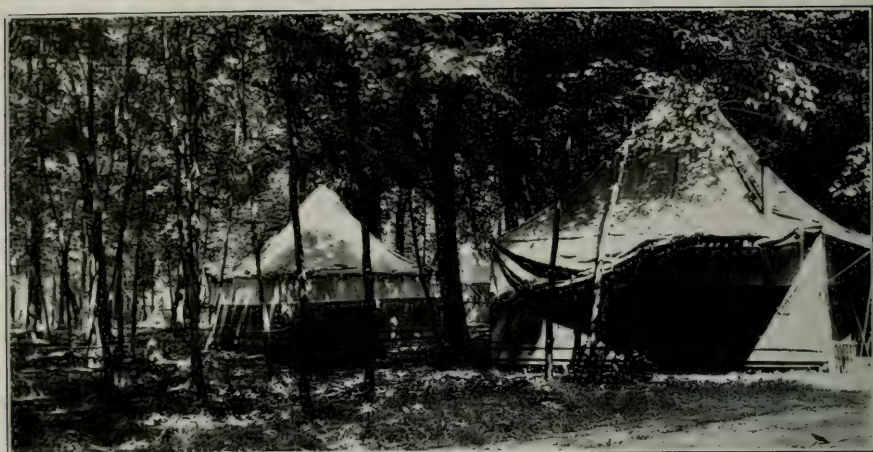


FIG. 148. Forest recreation: Summer camps in a Cook County Forest Preserve.



FIG. 149. Forest recreation: Girl scout camp in a Cook County Forest Preserve.

River, in order to increase the depth of the water in summer and provide better facilities for boating and bathing. These are combination dams and fords, built of reinforced concrete, so arranged that at the flood times of the river the water can flow over them after the iron railings are removed. Permanent cabins for Boy and Girl Scouts and a Fresh Air Camp are also maintained, and camping privileges are allowed to private individuals.

The management of preserves where recreation is a paramount feature places a great responsibility upon the forester in charge of them. He is not only confronted with the task of providing for the comfort of visitors and furnishing them with recreation of various kinds, but he is at the same time responsible for the perpetuation of the woods, since the admission of the public adds greatly to the danger of fires, of trespass, and of destruction by the vandals who will pick flowers and destroy the trees and shrubbery. The problem of maintaining the requisite number of trees per acre by natural reproduction is also exceedingly difficult even if there is a very large acreage, when the forest preserve is subjected to the trampling of thousands of persons. This may necessitate the rotation of areas, just as is done on grazed forests, so that a certain area after being open, is closed until it recovers from the destructive effects of trampling out the undergrowth.

Winnebago County Forest Preserves: The Winnebago County Forest Preserves came into being July 19, 1924, when Mr. T. G. Lindquist, a graduate of the Michigan Agricultural College, was employed as Chief Forester and placed in charge of a newly purchased tract of 95 acres. This tract, known as Hononegah Park, is situated some 15 miles to the north of Rockford and borders on the Rock River. Approximately one-third of it is creek bottomland, another third is upland timbered almost entirely by oak, and the last third is river bottomland shaded by stately elms, amongst which are ashes, maples, willows, Box Elder, and nut-trees as well as hawthorns and oaks.

Another tract, 75 acres in extent, is located on the banks of Kilbuck Creek, 10 miles south of Rockford, and is known as Kilbuck Bluffs.

By successive acquisitions of land, there are now 716 acres included in these preserves, and an ultimate goal of 3,000 acres has been set. So far, the greater part of the work that has been done has been in Hononegah Park and has included the clearing away of old buildings, remodeling of buildings for a caretaker, the building of roads, and providing for the comfort of the public.

In 1927, over half a million people visited the Winnebago County Forest Preserves. But in order to increase the usefulness of the preserves, the program calls for the reforestation of open or cleared spaces

by the planting of 50,000 young trees yearly and the construction of good roads. The yearly budget, including provisions for salaries and for the purchasing of new lands, is now about \$63,000.

Municipal Preserves: In addition to the large preserves maintained by counties, there are many towns in the State which maintain timbered areas. Among these towns are Monmouth, Knoxville, Joliet, Dixon, Galesburg, and Ottawa. Here, also, recreation is the principal purpose for which woodlands are kept.

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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
NATURAL HISTORY SURVEY

STEPHEN A. FORBES, *Chief*

Vol. XVIII.

BULLETIN

Article II.

Fall and Winter Stoneflies, or Plecoptera, of Illinois

BY

THEODORE H. FRISON



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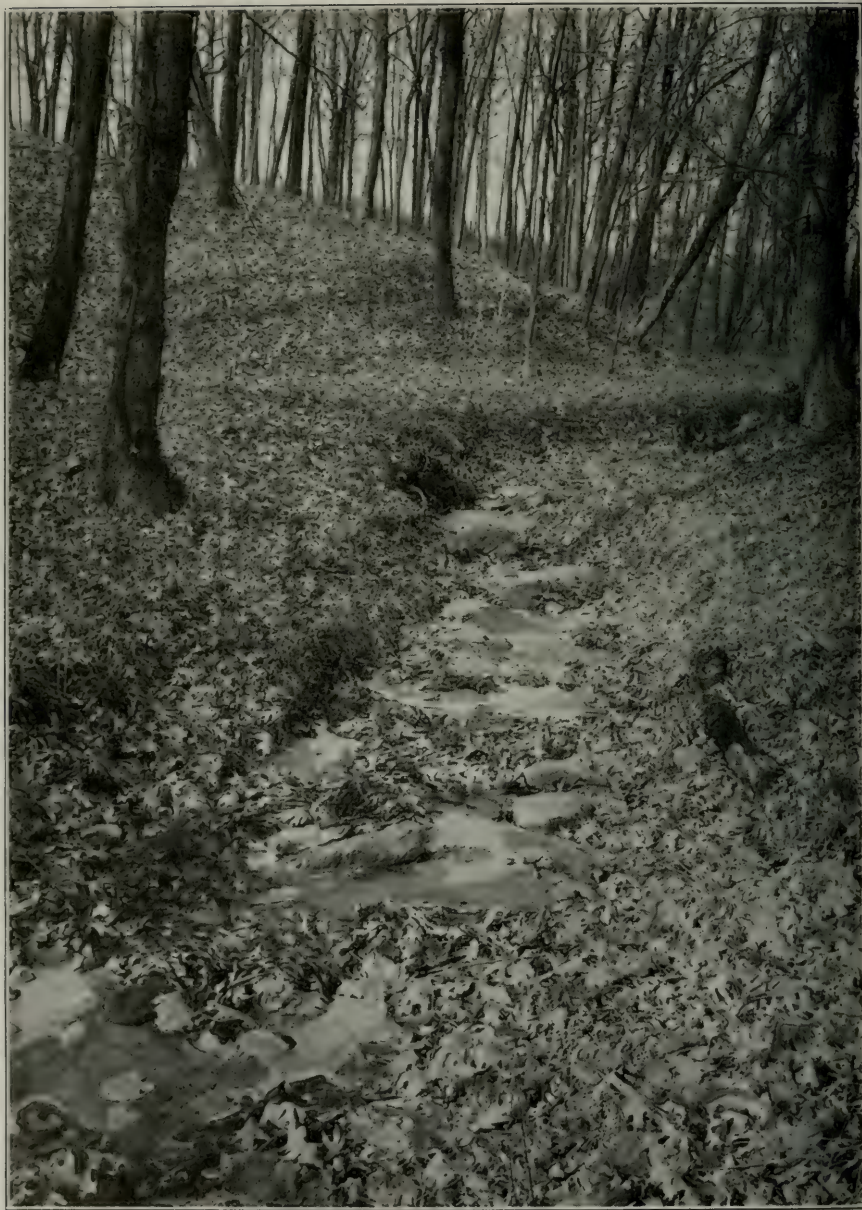


Fig. 1. View of a small brook (Station IV) two miles south of Oakwood, Illinois. Habitat of two species of fall and winter stoneflies, *Allocapnia recta* (Claassen) and *A. vivipara* (Claassen). December 27, 1928.

FALL AND WINTER STONEFLIES, OR PLECOPTERA, OF ILLINOIS

THEODORE H. FRISON

The life of the fall and winter stoneflies is a striking exception to the general rule that insect activity ceases with the approach of cold weather. This rule holds true for the vast majority of insects living in temperate climates, particularly for those kinds which are conspicuous because of their large size, their bright coloring, or the damage that they do. To certain other insects, however, usually of smaller proportions and duller hues, a chilling temperature is the signal for their greatest activity, their most pronounced growth, and the reproduction of their kind. Many years ago (1847) Asa Fitch, the first state entomologist of New York, said of them: "They are the objects of curiosity, as coming forth to our view in full maturity and vigor, at that time of year when almost every other member of the animal and vegetable kingdoms is reposing in torpidity under the chilling influence of solstitial cold." At least ten species of stoneflies in Illinois respond to cold weather in this way. To anyone not well acquainted with our fall and winter fauna, it is a startling revelation to see such large insects sprightly climbing up tree trunks in search of food when temperatures are near or below freezing, or to watch them crawling over the ice and snow which partly holds in its embrace the waters that nurtured their infancy. Such phenomena cannot fail to excite wonder and forcefully bring to mind the wonderful adaptiveness of the insect world—one of the chief reasons why insects so out-number all other kinds of animal life.

Even students of the great out-of-doors are for the most part unaware of the numerical abundance and importance of our winter insect fauna. Although myself a lover of the woods and fields of central Illinois for many years and acquainted with them in their various moods, the active fall and winter insect fauna, particularly the stoneflies, did not attract my attention until November, three winters ago. Then a chance examination of a small but charming brooklet south of Oakwood, Illinois, proved a revelation and incited me to make a study of the more salient features of the bionomics and classification of our fall and winter stoneflies. Recourse to the literature of the subject soon revealed that almost nothing was known concerning the habits of these archaic aquatic insects, so that any data I might secure would be worth recording.

Because of the richness of the fall and winter stonefly fauna in the vicinity of Oakwood, which is not far from Urbana, that locality has been visited many times during the progress of the investigation, and it has been the center of most of the biological studies. The variety of species thriving in its several streams is no doubt due to the diversity of aquatic habitats there, and perhaps also to the relative freedom from pollution that the streams enjoy. The Salt Fork at many places in this part of its course flows over a stony bottom, and many of its small tributaries are rapid brooks of rocky character nestled in forested ravines. One area in particular has been intensively studied in relation to differences in distribution and biology of the different fall and winter stoneflies occurring there, and a sketch map of this area (Figure 2) is presented for convenience in referring to special places by station numbers. (Cf. Figures 1, 4, and 5.)



Fig. 2. Sketch map of the Oakwood area, showing stations where extensive collections of stoneflies were made. Scale: 1 inch equals 1 mile.

In order that comparative data might be secured concerning the kinds and distribution of the fall and winter stoneflies throughout Illinois, several collecting trips were made in November, March, and the first week of April to various sections of the state. In the course of these trips, collections were made at approximately fifty different places (Figure 3), and the data thus obtained give a good picture of the distribution of these insects in this state.

Because of their habit of congregating in places exposed to the warming influences of the sun's rays, most of the fall and winter stonefly adults have proved easy of capture. During the warmer days of late fall or early winter one is apt to see some of them energetically crawling about on exposed tree trunks, fence posts, or rocks located close to a stream inhabited by the nymphs, particularly if these objects are covered with an algal growth. The white concrete bridges (Figure 7) so characteristic of our highways throughout Illinois are very attractive to the adults and afford excellent collecting places. Here the insects are easily seen as they crawl about in the sun. With an automobile for transportation one can make many collections from diverse localities during a single day. Sometimes a hundred or more adults can be collected on one bridge and a complete census made of the species of the locality during a ten or fifteen minute stop. Since the adults as well as the nymphs are best preserved for study in a liquid medium, no special time-consuming tech-

nique is needed for their preservation; they can be placed directly in vials containing eighty per cent alcohol or a two per cent formalin solution. Pinned specimens shrivel badly and usually must be boiled a short time in potassium hydroxide before their structural details can be distinguished.

The insect life of our inland streams affords a most interesting and profitable field for investigation; and the sooner we learn to correctly place and evaluate this fauna, the sooner will we be in a position to formulate conclusions and generalizations of importance in our efforts to understand our aquatic resources and intelligently forward their use.

SUMMARY

In this paper are presented the results of an investigation of the biological and systematical characteristics of five genera, comprising eleven species, of the little-known fall and winter stoneflies occurring in Illinois. It has been found that these species differ biologically from one another in respect to their seasonal adjustments, the habitats they prefer, oviposition, and in many other details of their life histories. In opposition to general ideas concerning the food habits of the order as a whole, the adults as well as the nymphs were found to be herbivorous.

Because of a previous erroneous designation of a genotype, it has been necessary to replace the generic name of *Nephelopteryx* Klapalek with *Tacnionpteryx* Pictet (*sensu str.*), revive the name of *Brachyptera* for another generic complex perhaps endemic to the Palaearctic fauna, substitute *Tacnionema* Banks for a Nearctic complex, and erect a new Nearctic genus *Strophopteryx*. In order to facilitate the determination of the Illinois species, keys for the determination of the adults and nymphs to genera and species have been formulated, critical systematical and distributional information has been presented for each species, and three species new to science have been described (*Allocapnia mystica*, *Allocapnia forbesi*, and *Leuctra claasseni*).

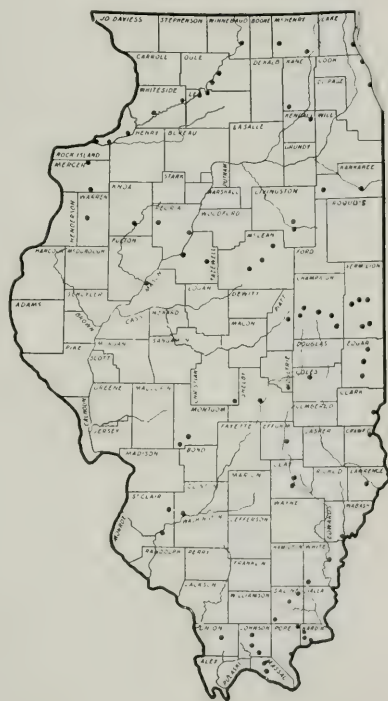


Fig. 3. Sketch map of Illinois, showing localities in which stoneflies were collected.



Fig. 4. View of the Salt Fork near Oakwood. Station O (in river) and Station I (mouth of brooklet at rocky edge of river). Habitat of *Taeniopteryx nivalis* (Fitch), *Strophopteryx fasciata* (Burmeister), *Allocapnia vivipara* (Claassen), and *A. granulata* (Claassen). December 27, 1928.



Fig. 5. View of Station VII, a small stream that flows into the Salt Fork about one mile below Station I. Habitat of *Allocapnia mystica* Frison and *A. vivipara* (Claassen). December 27, 1928.

ACKNOWLEDGMENTS

As in most investigations, the writer has been aided indirectly by the previous studies of other investigators and directly by various individuals. My assistants, Mr. H. H. Ross and Mr. A. R. Park, Jr., have been of service in the collection of material and in other ways. I am indebted to Dr. P. W. Claassen, of Cornell University, for a review of my identifications of adult specimens of certain species of stoneflies involved; to Mr. Samuel Eddy, of the University of Illinois and the Natural History Survey, for a determination of the small organisms used as food by the

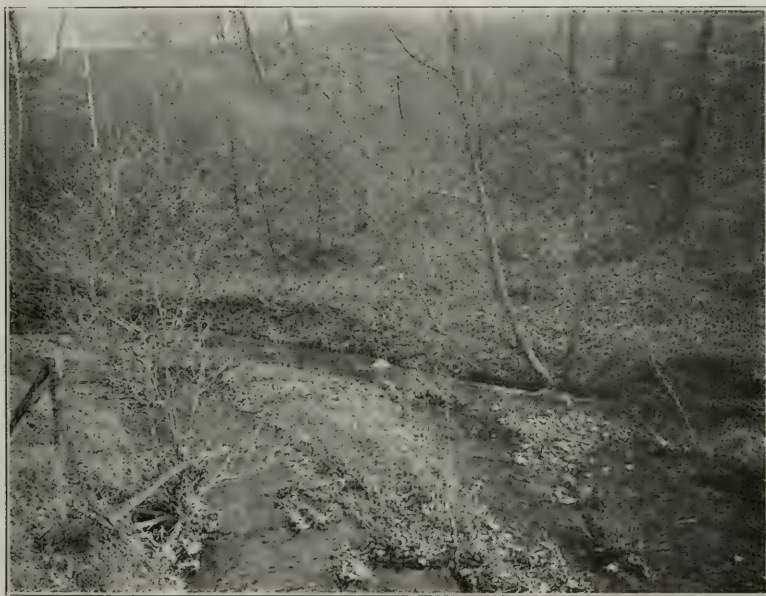


Fig. 6. View of a small tributary of the Middle Fork north of Oakwood. Habitat of *Allocapnia vivipara* (Claassen). December 27, 1928.

nymphs; to Mr. Carl Mohr, of the Natural History Survey and to Mrs. K. H. Paul, of the University of Illinois, for the preparation of the drawings; to Mr. A. G. Eldredge, of the University of Illinois, for the photographs; and to Mr. H. C. Oesterling, editor of Survey publications, for taking care of the final details incidental to the publication of this paper. Mention should be made, too, of the aid given by Dr. R. D. Glasgow and his companionship on many of my unofficial week-end trips to the Oakwood region.



Fig. 7. View at bridge over Stony Creek on State Route 10, east of Muncie. Adults of fall and winter stoneflies congregate on such bridges. December 27, 1928.



Fig. 8. View of Stony Creek east of Muncie, Illinois, October 25, 1927. Nymphs of *Taeniopteryx nivalis* (Fitch) very abundant in partly submerged leaves lodged against rocks.

BIOLOGY

To date, the writer has collected and closely studied six species of stoneflies from Illinois which are to be truly assigned to the fall or winter insect fauna. Two of these, *nivalis* (Fitch) and *fasciata* (Burmeister), are moderately large (13-16 mm.) and belong respectively to the genera *Taeniopteryx* Pictet and *Strophopteryx* Frison. Four forms, *mystica* Frison, *recta* (Claassen), *granulata* (Claassen) and *vivipara* (Claassen) are comparatively small (6-10 mm.) and belong to the genus *Allocapnia* Claassen. All of these species have their most rapid nymphal growth at various times during the fall and winter months and reach adulthood in Illinois during late November, December, January, February, or March. A few stragglers are still to be found during the first of April, but the peak of their abundance and the time of their greatest activity is then past. In addition to those just enumerated, four species—*Taeniopteryx parvula* Banks, *Leuctra claasseni* Frison, *Allocapnia pygmaea* (Burmeister), and *Allocapnia forbesi* Frison—have been collected in the adult stage in this state during the winter season, and sufficient information obtained to show that they belong to the true winter fauna. The nymphs of three of them, *T. parvula*, *L. claasseni*, and *A. pygmaea*, have been discovered for a certainty and some biological data secured concerning them. One other species, an undeterminable species of the genus *Capnia* Pictet, was collected during the first part of March and probably belongs to the true winter insect fauna. The latter cannot be positively named to species at the present time because it is represented in our collection by a unique female specimen, and thus far no one has been able to separate the various females belonging to this genus or to properly associate them with the easily differentiated males. Because *Capnia vernalis* Newport is the only species of this genus occurring east of the Rocky Mountains, it is likely that the Illinois specimen in question is this species or new.

Seasonal Adjustments

Numerous collections and observations in the Oakwood area have demonstrated that there is a rather definite succession in the time of appearance of the adults of the various species of fall and winter stoneflies and that all of them have one generation a year. One other North American stonefly (*Nemoura vallicularia* Wu) has been found by Wu (1923) to have one generation a year. In Europe, Mertens (1923) and Schoenemund (1925) have shown that several small forms inhabiting streams, and closely related to those mentioned in this paper, have a single generation a year. Accordingly, a generalization can be drawn that small plecopteran species, particularly those appearing in fall and winter, have a single generation each year in contrast to the larger species flying in spring or summer which may require two or three years for their development. During the past two years I visited and made extensive collections and observations no less than twenty-eight times at Stations I, II, III, and IV in the Oakwood area. On these trips over four thousand

specimens of adults and nymphs were collected and later critically studied, while numerous other specimens were observed but not collected. The number of specimens studied is sufficient to preclude a misinterpretation of the seasonal successional data, at least concerning the adults of five species occurring in the same locality. The fact that the adults show a marked succession in time of their emergence is indicative, also, that there are corresponding differences in the length of the egg and nymphal stages. Such information as has been gathered regarding this subject is presented under a discussion of the habits of nymphs.

In 1926, the first collection at Oakwood was made on November 28. Except for one on December 4, no further collections were made until February 24, 1927, after which numerous collections were made until the winter stoneflies disappeared. The late date of starting in the winter of 1926-27 and the long interval between the first and later observations, preclude the use of these data alone for evidence of a definite succession of species.

The years of 1927 and 1928, however, have supplied sufficient data from which to draw reliable conclusions. Search was made for the first stages of the winter stonefly nymphs at various times and at various stations during the summer months of 1927, and beginning on September 1, frequent collections were made to determine the matter in question.

Without going into great detail or presenting a tabulation of all the findings, it will suffice here to report only the gist of these records and observations under the specific name of each species of fall or winter stonefly found in Illinois. The status of two species as true representatives of the winter fauna is possibly open to slight question, but since all available evidence suggests that they are true winter stoneflies, they should be considered along with the others.

Allocaënia recta (Claassen)

In 1926, as well as in 1927 and 1928, the first adults found at any of the Oakwood Stations belonged to *A. recta*, the smallest of all the fall or winter stoneflies I have studied. Adults were found at the very beginning of my studies on November 28, 1926. In the late fall of 1927, adults were first discovered on November 20, and in 1928 on November 18, and it was evident from their numbers and proved by subsequent collections that the period of their emergence had just started. The maximum abundance of the adults was in December, both in 1927 and 1928. After this month the number of adults present rapidly declined, and by the last of March the species was comparatively a rarity.

Since no specimens of this species have been collected in Illinois outside of the Oakwood area, no data are available for comparisons with seasonal adjustments in other parts of the state. Collecting trips in November, March, and the first of April to various parts of the state have failed to produce a single specimen of this species—an indication that if *A. recta* occurs in other parts of the state, as it surely must, it is a rarity. This species is apparently the earliest of our winter stoneflies to reach maturity, arriving at its maximum abundance in December and thereafter gradually diminishing in numbers until there is no readily discernible evidence of its presence.

Allocapnia vivipara (Claassen)

A. vivipara is the next species to appear on the scene in the Oakwood area after *A. recta* has made its début, but the emergence of the adults is not so concentrated or uniform. A few specimens, mostly males, were found during the early part of December in 1927 and the latter part of the same month in 1928, but the time of their maximum abundance was not reached until the first or second week of March. By the last of March only a few stragglers were to be found.

Collecting in various parts of Illinois has confirmed the main generalizations concerning the seasonal adjustments of the adults of this species as worked out for the Oakwood area. Adults of this species were taken in December at Ft. Sheridan, the typic locality of the species, and hundreds of them were taken in various parts of the state in February and March. In the vicinity of Barstow (northwestern Illinois) they were apparently at their maximum abundance on April 2, 1928. This was about two weeks later than the date for the maximum abundance at Urbana (central Illinois), and about a month later than at Herod (southern Illinois in the Ozarkian Uplift).

Allocapnia granulata (Claassen)

Unlike either *A. recta* or *A. vivipara*, no specimens of *A. granulata* have been taken in the Oakwood area in the month of December. In January, on mild days when crevices appear in the ice along the river bank and a little open water is to be found here and there, the adults of this species come forth to crawl about on the rocks, snow, or ice. Although they are common in January under certain conditions, the main concentration of them comes during the latter part of February and in March, and a few can still be found during the first of April.

In southern Illinois only a few specimens of this species were found on March 5-7, 1928; if the species was abundant there, its maximum abundance had passed some weeks previous to our trip. In northern and north-central Illinois, some specimens were collected during the last of March and the first of April.

Allocapnia pygmaea (Burmeister)

All of the species of *A. pygmaea* taken in Illinois have been from the extreme southern part, in the region of the Ozarkian Uplift. They were collected on March 6-7, 1928. Sufficient data are available from collections in other parts of the state, especially the Oakwood area, to prove that this species is essentially an element of the fauna of southern Illinois. Since this was the dominant species in March, 1927, and no adults were found at the same localities in November, 1928, it evidently reached its greatest abundance about the first of March. Probably some specimens appear in January and February.

Allocapnia mystica Frison

Although *A. mystica* was not discovered until the late fall of 1928, there is ample evidence that it is a true member of the fall fauna. It was common when first found near Oakwood on November 18. A few days later at the same place the adults were exceedingly abundant and continued to be so during the first part of December, but by the end of that month the maximum of their

abundance had passed and they were diminishing in number. In southern Illinois this species was found to have the same seasonal adjustment as in central Illinois; it was very common the last of November in the vicinity of small streams where it had been found very rarely or not at all in March of the same year. The few adults collected in southern Illinois in March, when *A. pygmaea* and *A. vivipara* were the dominant species, were merely stragglers out of step, for some reason or other, with the usual time of appearance of the species. The same is true, also, of the adults found in the Oakwood area in February.

Allocapnia forbesi Frison

This easily recognized species, new to science, was first found at two separate southern localities (Stonefort and Cobden) on March 4-7, 1928. Since only four specimens were taken at this season, it was surmised either that this was the rarest of the Illinois species of *Allocapnia* or that the time of the maximum production of the adults was in fall. Collecting near Herod in November, 1928, demonstrated that *A. forbesi* is a true member of the fall fauna and that the specimens collected in March were stragglers. Since no members of this genus were found in the adult stage when this territory was visited on another mission in the latter part of October, 1928, it is evident that they first appear in November.

Tacniopteryx nivalis (Fitch)

This moderately large species is distributed throughout Illinois and is our most abundant species. To date, specimens have been taken in more than fifty different places, and there is apparently no reason why *T. nivalis* could not be collected in any county in the state during February or March. In 1928, a close watch was kept in the Oakwood area for the appearance of the first adults of this species, with the result that a few were collected as early as January 2. From this time onward, an increasing number of adults were to be found during the warmer parts of the milder days; the maximum abundance, however, was from February 11 to the middle of March. Afterwards their numbers gradually diminished, and though some were still to be found the last of March, they were but a remnant of the countless horde that earlier basked in the sunshine on the trestle works of an iron road bridge, swarmed over stones at the river's edge, and crawled over tree trunks in search of food. Data for 1927 indicate the same seasonal adjustments as just presented for 1928, and quantitative sampling on February 26, 1927, revealed that *T. nivalis* then outnumbered *S. fasciata* by about 10 to 1.

In northern Illinois the time of the maximum abundance of the adults is no doubt later than for the Oakwood area, as shown by the capture of adults and even nymphs on our northern trip during the first week of April. The reverse of this may be said for southern Illinois, because on our southern trip, March 7-9, ample evidence was obtained that the maximum abundance of the adults was past. No adults were to be found, however, in southern Illinois at the time of our fall trip the last of November, 1928.

Tacniopteryx parvula Banks

Since *T. parvula* is lacking in the Oakwood area and is not numerous in other localities in Illinois, no consecutive data are available for comparative

studies of its seasonal adjustments. Specimens have been taken at six localities along the Rock River in northern Illinois, at Grayville along the Wabash River, and at Elizabethtown along the Ohio River. Apparently this species is confined to the larger rivers, and further collecting should produce specimens from localities near the Mississippi and the Illinois. The earliest record we have for this species is March 7 and the latest record is April 23.

Strophopteryx fasciata (Burmeister)

Although never as abundant as *T. nivalis* in the Oakwood area, *S. fasciata* is a common winter stonefly in Illinois and has been taken at thirty-one different places. This species does not appear as early as *nivalis*, its earliest record from Oakwood being on February 3, 1928. Its maximum abundance at this locality in 1927-28 was reached during the last half of March, so that it was the dominant species after *nivalis* had passed along.

Additional data were found in other sections of Illinois showing that the maximum abundance of *fasciata* follows that of *nivalis*. At Grayville, Illinois, visited on our southern trip on March 8, 1928, nymphs as well as adults of *fasciata* were collected, the nymphs being particularly indicative of the lateness of appearance of the adults. Nearly a month later at Rock Island, in northwestern Illinois, the adults of this species were very numerous and *T. nivalis* almost a rarity.

Leuctra claasseni Frison

This new species is undoubtedly a rarity in Illinois and unlikely to be found outside of the southern part of the state. The two adults and ten nymphs, the specimens from which the species is described, were collected in a small rocky stream near Herod, Illinois, on March 8, 1928. Exact information regarding the maximum abundance of the adults awaits further investigations. Judging by the size of the nymphs, which were not common, the adults were just beginning to appear.

Capnia sp.

Evidently another rare species in Illinois and probably absent in the northern part of the state. Unidentifiable to species for the reasons previously stated. Aside from its probable place in the winter-fauna, nothing is known of its biology.

Habitat Preferences

The blanket statement that the nymphs of stoneflies are aquatic has generally sufficed in the past as a summary of their habitat preferences. Rather recently in Europe, where the most work on the biology of the stoneflies has been done, a good beginning in the association of nymphs with definite habitats or communities has been made by Neeracher (1910), Rousseau (1921), Mertens (1923), and Schoenemund (1925). In America, less has been done; only a few statements regarding habitat preferences are in our literature (Smith, 1913 and 1917, and Wu, 1923), and almost nothing in a comparative manner has ever been attempted. Increasing interest in studies of the biology of river systems and their tributaries will no doubt eventually lead to a good ecological classification

of them, and with the coming of this more exacting nomenclature there will be a stronger demand for the proper assignment of the various organisms living there to the many communities represented.

Considerable information was obtained during the last two years regarding the grosser habitat preferences of the nymphs of the fall and winter stoneflies of Illinois, particularly the six species found in the Oakwood area. Since these insects spend the greater part of their lives in the nymphal stage, in which they are most dependent upon a relatively stable or fixed environment, this stage has been considered as the best or true criterion of their basic habitat preference.

TAENIOPTERYX and STROPHOPTERYX

In the area represented by Figure 4 the nymphs of five species of fall and winter stoneflies can be collected within a radius of fifty feet, but there are, nevertheless, certain marked differences in habitat preferences among these species. The nymphs of *T. nivalis* and *S. fasciata* are never found in the small brook flowing into the Salt Fork, except when a few of them are carried by floods into Station II and stranded there with the return of low water. On the many occasions that I have visited this area when the adults of *Taeniopteryx* and *Strophopteryx* were flying and laying eggs, I have never seen them deposit their eggs at Stations II, III, or IV, but always in the middle or near the edge of the river itself (Station O). The collection of nymphs and adults of *Taeniopteryx* and *Strophopteryx* in various parts of the state has furnished additional evidence that the members of these genera in Illinois prefer the larger water courses which never become dry or reduced to small pool stages during the summer or fall of the year.

It was likewise found that the nymphs of *T. nivalis* and *S. fasciata* are not identical in respect to the community in which they prefer to develop, aside from their common preference for a permanent water flow in streams ranging from the size of the Salt Fork, near Urbana, to such large rivers as the Wabash, near Grayville. The nymphs of *T. nivalis* are especially abundant in clusters of decaying leaves which, when falling or washed into the river, are caught and held by the current of the stream against rocks and willows or lodged against the shore (Figure 8), and then later submerged or partly submerged in water and silt. The nymphs of *S. fasciata*, however, seem to have an antipathy for muddy debris of this character, preferring to crawl about small stones and pebbles in clearer water. When the water is very clear they may be seen at Oakwood (Station I) crawling around on the rocky floor of the river. It seems probable that the amount of dissolved oxygen or the hydrogen-ion concentration is different in these two situations and that *T. nivalis* is able to thrive by virtue of its extraordinary coxal tracheal appendages (Figure 41) in situations where *S. fasciata*, which lacks such appendages, is at a disadvantage. Although the biology of nymphs of *T. parvula* has not been closely studied, it has been found that they frequent the larger rivers. Because of their close affinity with *nivalis* and the presence of coxal tracheal appendages, it can be safely inferred that they frequent situations similar to those preferred by *nivalis*.

ALLOCAPNIA

The species of *Allocapnia* exhibit a wide degree of diversity in regard to the communities which they prefer. In the Oakwood area the nymphs of *A. granulata* are found both in the river (Stations O and I) in company with *T. nivalis* and *S. fasciata*, and also in masses of submerged and decaying leaves in the brook at Stations II and III. They are most abundant at the river's edge and at Station II where the brook is overflowed by the river during high water—always, however, in association with decaying vegetation. Additional data showing that *granulata* prefers larger streams with a good permanent flow are furnished by collections made in other parts of Illinois. In fact, *granulata* has been collected at sufficient localities in Illinois to indicate its general distribution within the state, particularly the central and northern portions, and its association with such major river systems as the Rock, Illinois, Sangamon, Kankakee, Vermillion, and Wabash.

A. recta thus far has been found in Illinois only in the Oakwood area, where it occurs in three small streams within a seven-mile radius. In all cases the habitat is the same—a small brook (Figure 1), with considerable decaying organic matter, usually clear except immediately after heavy rains, and reduced at certain times of the year to small pool stages. The nymphs are found on the bottom of the stream, particularly under and between deposits of decaying leaves. Thus, *A. recta* differs markedly from *A. granulata* in respect to type of stream preferred for its development.

A somewhat intermediate condition between *A. granulata* and *A. recta* in regard to habitat preference is exhibited by *A. vivipara*, a species found in all parts of Illinois. At Urbana a few specimens can usually be found in company with *A. granulata* along the course of the Salt Fork, and the same applies to other rivers in all parts of Illinois where collections have been made. However, our collecting is sufficient to show that the habitat where the greatest concentration of both nymphs and adults are to be found, is a small brook with a sandy and rocky bottom, cluttered with decaying leaves, which may or may not reach a small pool stage at certain times of the year. In the Oakwood area, careful collecting is certain to reveal a few specimens almost anywhere along the course of the Salt Fork, but they are more abundant at Stations II, III, and IV and in other similar brooks. A similar state of affairs was observed in the vicinity of Rock Island in 1928, when a small brook near Barstow, with a sandy and rocky bottom, produced seventy-four males, twenty-five females, and numerous nymphs and nymphal skins in a few minutes of collecting, whereas along the nearby shores of the Rock River the species was rare. A comparable example is known, also, in the vicinity of Mahomet. In southern Illinois, *vivipara* is abundant in the numerous small streams of the Ozarkian Uplift and, though associated also with the larger streams, is less abundant in them.

Although restricted to extreme southern Illinois, sufficient data have been collected to show that *A. pygmaea* is nearly similar to *A. vivipara* in respect to type of stream which it prefers. Large numbers of this species were found near Golconda in shallow, stony stretches of the Big Grand Pierre River where

decaying organic matter had lodged, but it was even more numerous in the small streams (Bushy Fork, Rose Creek, Gibbon's Creek, etc.) in the Ozarkian Uplift proper, streams which reach small pool stages at certain times of the year.

The preferred habitat of *A. mystica* is to all general appearances the same as that of *A. recta* and *A. pygmaea*, except that streams containing *mystica* have averaged somewhat larger in size though still reduced at times to a small pool stage. The distribution of *mystica* in the Oakwood area, however, is so freakish that one cannot help wondering whether more subtle factors are operating. Just why *mystica* does not occur in the small brook at Stations II or IV in association with *recta* and *vivipara* is a mystery, in view of its abundance and association with *vivipara* in another slightly larger stream emptying into the Salt Fork about one-half mile downstream. A superficial survey of the two streams reveals no marked differences in their physical make-up or watersheds. Considering the low temperature of the water at the time of the nymphal development, a difference in dissolved oxygen content would not seem to answer the question. Perhaps we are here dealing with a merely fortuitous distribution.

When sufficiently abundant, the adults of fall and winter stoneflies in the aggregate serve as a good guide to the basic habitat of the nymphs, for they tend to remain for a time in the neighborhood where they emerge and the females also deposit their eggs there. This, however, does not hold for individual adults, many of which may be captured some distance from the place of their nymphal development, having wandered or flown far in search of food or aimlessly drifted with the wind. On many occasions I have seen winter stoneflies, particularly the large *Taeniopteryx*, flying miles from any place that could have served for the development of the nymphs.

The lack of wings in the males of *A. vivipara*, and often their shortness in the females, prevent some adults of this species migrating in any numbers to great distances from the place of their birth. The farthest I have found such individuals from a place where they might have developed, was only a few hundred feet, and then usually on bridges over the stream or on nearby tree trunks. The females of *A. granulata*, however, are well equipped for flying and, like *T. nivalis* and *S. fasciata*, may travel miles from the place of their origin. Although provided with wings, the females of *A. recta*, *A. mystica*, or *A. pygmaea* have never been observed flying about over streams as have those of *A. granulata*. When disturbed while feeding on the trunk of a tree or resting on a post or bridge, they half drop and half fly to the ground and often are carried by the wind for a distance of several yards. Judging by the extent of development of their wings, however, there is no apparent reason why some of them should not fly well. Since the males of *A. recta*, *A. pygmaea*, *A. mystica*, and *A. forbesi* have much shorter wings than the females, the probabilities of their wandering far from their nymphal habitat are reduced, and I have never found them except upon bridges, trees, etc., nearby.

Habits of Adults

FEEDING

Smith (1910) in his classical report of the "Insects of New Jersey," stated that adult stoneflies "do no feeding upon living plants as far as known," and Rousseau (1921) in his extensive work on the aquatic larvae and nymphs of Europe said that the stonefly adult "ne prend pas de nourriture car sa bouche est atrophiée." It has been discovered, however, by Newcomer (1918) that several western species of *Taenionema* (*nigripennis* Banks, *pallida* Banks and *pacifica* Banks) feed upon the buds and leaves of plants and that one species in particular, *pacifica* Banks, sometimes causes serious injury to apricot and peach orchards in Washington. Wu (1923) has found, too, that some adults of *Nemoura vancouveriana* Wu will feed a little upon parts of the young leaves of the touch-me-not (*Impatiens*).

In view of the general belief that adults of stoneflies which feed are the exception to the rule, it was with considerable interest that I found all of the fall and winter species of the Oakwood area to be feeding. My first intimation of this fact came about in an unusual manner. On March 5, 1927, some live adults of *Taeniopteryx nivalis* were collected at Oakwood and brought to the laboratory at Urbana for further observations. Several days later, much to my amazement, I saw the sole remaining live specimen playing the role of a cannibal and feeding upon a dead specimen of its fellow species. After this a careful watch was kept for adults feeding under natural conditions.

On my next trip to Oakwood, March 10, many winter stoneflies were seen crawling up and down on tree trunks (Figure 9) and feeding upon blue-green algae (*Protococcus vulgaris* Meneghini) near Stations III and IV. The majority of these specimens were males and females of *T. nivalis* and *A. granulata*, the dominant species at the time. A few others proved to be *A. recta* and *A. vivipara*. Many females of *T. nivalis* and *A. granulata*, particularly the former, continued their search for food while mat-

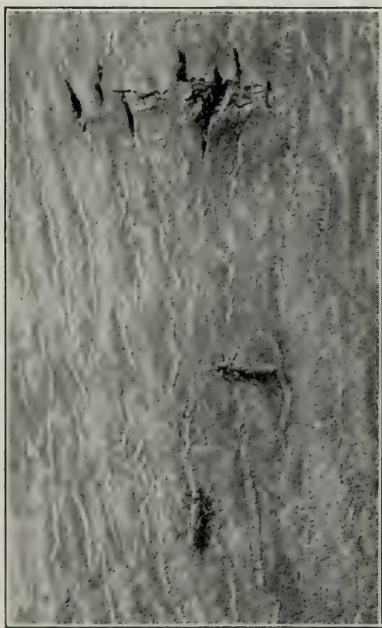


Fig. 9. Adult females of *Allocapnia mystica* Frison feeding on algae on tree trunk at Station VII, December 27, 1928.

ing with the males, the latter being carried around on their backs wherever they went.

In 1928, on many occasions near Oakwood, the adults of *T. nivalis*, *A. recta*, *A. vivipara*, *A. mystica*, and *A. granulata* were observed feeding upon blue-green algae growing on tree trunks, stones, old logs, etc., near their habitats. Because of the fact that *S. fasciata* was not found at Oakwood feeding in company with the other fall and winter stoneflies, a careful search was made elsewhere. This search was finally rewarded on April 3, 1928, when thousands of this species were found feeding on the blossoms of elm trees near Grand Detour on the Rock River. The elms were so situated along the river and next to the road that one driving on the road was nearly on the level with their topmost branches where the adults were feeding. It seems probable from this observation that the adults of *fasciata* prefer to feed in the tops of trees, and some of the many large winter stoneflies seen from the ground in the tops of trees in the Oakwood area were likely the species *fasciata*. In addition to the species already mentioned, I have observed many adults of *A. pygmaea* and *A. forbesi* feeding on algae on tree trunks, fence posts, and stones near the habitat of the nymphs in the Ozarkian Uplift, and a single specimen of *T. parvula* feeding on algae on a tree trunk along the Rock River at Dixon.

It has thus been found that all Illinois species of *Taeniopteryx*, *Strophopteryx*, and *Allocapnia* take food when in the adult stage. Information concerning the rare winter species, *Leuctra claasseni* and *Capnia* sp., is still lacking, but in view of the development of their mouthparts and the habits of other species, I believe that they also feed. Whether the fall and winter stoneflies, especially the females, must feed in order to carry on their life processes, has not been conclusively proved. In cages in the laboratory the adults of *Allocapnia vivipara* and *mystica*, particularly the females, are voracious feeders, and under natural conditions they devote themselves most zealously to the same task. When one considers that the adults may live a month or more under natural conditions, that on many days they are very energetic for hours at a time, and that the females produce a very large number of eggs, it seems that the adults feed from necessity and not because of an idle inclination or impulse. If a few more of the Illinois species of stoneflies appearing as adults in spring and summer are found to feed, the current and general statement that most adults of stoneflies do not feed must be reversed.

Although Newcomer (1918) reports that *Taeniopteryx* (= *Taenio-nema*) has caused serious injury to buds of fruit trees and even to the fruit itself in Washington, it is likely that such damage is very rarely, if ever, caused by near allies in Illinois. This statement is based mainly upon the fact that most of the winter stoneflies of Illinois reach their greatest abundance before most fruit trees are sufficiently advanced to permit injury and because of the rather local and restricted distribution of the insects. It is interesting to note, however, that Newcomer's figures of peaches showing injury are reminiscent of the so-called "cat-facing" produced on peaches in Illinois by various hemipterous insects.

MATING

Mating of the fall and winter stoneflies of Illinois takes place during the daytime, and particularly on comparatively warm days when the sun is shining. As soon as the adults of a species become abundant, mating pairs can be seen resting on the concrete foundations of bridges, on tree trunks, or stones, etc., near the water's edge. The time at which mating reaches its maximum varies with the species and has a direct correlation with the seasonal adjustments of the adults. It is not surprising, then, that mating pairs of *A. recta* and *A. mystica* have been found in the latter part of November, and those of *A. vivipara* during the middle of December. Mating pairs of *T. nivalis*, *A. vivipara*, and *A. granulata* are very common near Oakwood beginning the latter part of February, but those of *S. fasciata* are less frequently seen, perhaps because of their preference for the higher parts of trees while feeding.

During mating, the male rests upon the back of the female, with the middle portion of his abdomen dropped below the level of hers and with the end segments recurved forward and upward again, grasshopper fashion, so that the genital structures of the male and female come into apposition. When an unengaged male approaches a mating pair, the male already in possession of the female spasmodically vibrates his wings as if to scare or knock away the intruding male. Occasionally, too, the males move their antennae forward in line with those of the females and vibrate them rapidly. It is very apparent from the degree of coloring of the body, flabbiness of wings, and comparative attractiveness to the males that most of the females mate soon after emergence—a characteristic of many insects. The maximum abundance of the males is attained before the maximum abundance of the females, and this proterandry is a wise provision of nature since the females mate very early in life. It was observed at one locality in the Oakwood region (Figure 6), where only *A. vivipara* has been found, that the males sometimes mated with the females within a few minutes after the latter had left their nymphal toggery. After once mating it is doubtful whether copulation is repeated by the females. In the laboratory in cages containing males and females of *A. vivipara*, the latter known to have mated soon after emergence, the males continued now and then for many days to ride around on the back of the females while attempting to mate, but they were never again observed in actual copulation.

OVIPOSITION

A marked difference in egg-laying habits was found to exist in the Oakwood region between the species of fall and winter stoneflies inhabiting large streams and those living in small brooks. Those preferring large streams, such as *T. nivalis*, *S. fasciata*, and *A. granulata*, usually deposit their eggs directly in the river, particularly at rapids where the swirling and turbulent water sparkles in the sunshine on bright days. A short time previous to the deposition of the eggs (Figure 10) the females of these species seek resting places on bridges, trees, and other objects near

the river and by a rhythmic contraction of the abdomen gradually force from the oviduct, a little at a time, a matrix containing many eggs. One such egg mass, produced by a female of *T. nivalis*, contained 1407 eggs; and it is probable, judging by their size, that most egg masses of *T. nivalis*, *S. fasciata*, and *A. granulata* contain approximately the same number.

These three species differ, as a rule, in the manner of holding the egg mass while it is being formed. The female of *S. fasciata* keeps her abdomen extended for its full length almost horizontal, or parallel with the object on which she rests, so that the egg mass, which is rather irregular in shape, is partly concealed beneath the abdomen. *T. nivalis*, and to a still greater extent *A. granulata*, bends the end of the abdomen upward and forward, so that the usually globular egg mass is much more easily seen and a superficial observation might cause one to think it was being carried on the back of the abdomen.

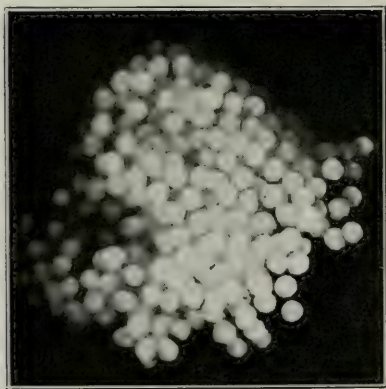


Fig. 10. Eggs of *Taeniopteryx nivalis* (Fitch).

doubt, some females of *Taeniopteryx* and *Strophopteryx* crawl with their egg masses to the water's edge and deposit their eggs, and I have seen such a performance upon the part of a female of *A. granulata*.

Unfortunately for the individual, but of no consequence from the standpoint of the preservation of the species, some females after alighting upon the surface of the water and depositing their egg masses become ensnared by the water, and if they do not come into contact with some object upon which they can crawl out of it, they eventually drown. On February 27, 1928, at Oakwood, I made a ten-minute collection of stoneflies floating on the water past the rocks at Station I with the following results: 54 ♀ and 8 ♂ of *T. nivalis*, 81 ♀ and 5 ♂ of *A. granulata*, and 4 ♀ and 3 ♂ of *S. fasciata* (not abundant at the time). This collection bears mute testimony to the numbers of females that fail to rise

By the simple expedient of catching females with egg masses and submerging them in water, it was found that the egg masses soon fall from the female, the matrix holding together the numerous eggs dissolves, and the individual eggs separate. Subsequent observations showed that the females could voluntarily release the egg masses when ready to do so, without awaiting the disintegrating effect of the water. It is possible that the egg masses are sometimes dropped into the water by the females without alighting upon it, but in the instances witnessed at close range, the females lighted upon the surface of the water, almost instantly released their egg masses, and then flew up and away again. No

from the water again when once they descend to it to lay their eggs. Drowning with winter stonefly adults, however, is a slow process, and I have seen many of them slowly walking on the bottom of the river near its edge or crawling about under small drifting ice floes.

I have seen numerous females of *A. recta* and *A. mystica* with similar egg masses produced and carried in essentially the same manner as described for *A. granulata*. Several counts of the eggs produced by single females of *A. mystica* gave an average of about six hundred eggs per female.

Because *A. vivipara* has been stated to be viviparous by Claassen (1924), who records that nymphs as well as eggs were found in the abdomen of a female, a special effort was made to get information about this species. A large number of freshly emerged and mated females were collected in December, 1928, and isolated in the laboratory in a cage containing their favorite food—the alga *Protococcus vulgaris*—under conditions as nearly as possible suitable for the continuation of their life span. In this cage eleven females produced egg masses characteristic of the genus. One of these females was observed in the act of ejecting the eggs. She tilted the end of her abdomen upward only slightly, so that the egg mass did not appear to be carried on her back as is the case with the other species of *Allocapnia* in the Oakwood area. In fact, the peculiar fusion of the seventh and eighth ventral abdominal segments may prevent the eggs being hoisted over the back of the abdomen. Dissection of fifteen females of *A. vivipara* revealed no nymphs, but only eggs, the number of which varied from 211 to 412. Some of the egg masses of *A. vivipara* were deposited in drops of moisture condensing on the sides of the aquarium jar serving for their confinement, and others were laid directly in a small tin containing water which was placed in the cage expressly for this purpose. These observations indicate that the name *vivipara* is a misnomer, or at least the viviparous habit is not well established. When dissecting the abdomens of females in order to make a count of the eggs, it was found that the embryonic nymphs of this species are in a rather advanced stage when the eggs are laid. This has suggested the possibility that the nymphs observed by Claassen in a dissected female were disclosed by the accidental rupture of the egg shell. Additional and indirect evidence that *vivipara* is not viviparous is found in the fact that some eggs of this species placed on January 10 under suitable conditions for the emergence of the nymphs had not hatched by January 29; this is an indication that after the eggs are deposited in the water some time must elapse before the nymphs are sufficiently developed to emerge.

Much evidence was obtained in the Oakwood area to show that the females of *A. recta*, *A. mystica*, and *A. vivipara* rarely, if ever, fly over the brook in which they lay their eggs, and that they deliberately crawl into the water at its edge or at other places where stones, sticks, and leaves are partly submerged. Several times I found females of *A. recta* carrying egg masses into the water to release them. Since the females of *A. vivipara* are normally short-winged in this part of Illinois, it is easy to understand why some of them do little if any flying above the small

streams in which they lay their eggs, but in southern Illinois where there is a strong tendency for the females of this species to develop long wings, there is no such restriction upon their flying. There seems to be no good reason why *A. recta* and *A. mystica* do not fly more than they do.

MISCELLANEOUS ADJUSTMENTS

Although the adults of the fall and winter stoneflies of Illinois are obviously tolerant of cold weather, their activities are retarded by very low temperatures and accelerated by higher temperatures. During mid-winter a warm bright day or a succession of such days is sufficient to cause flying, feeding, mating, and other activities, and the return of colder weather is the signal for their curtailment. For example, on February 24, 1927, with an air temperature of 58° F. about 1 p. m., many adults of *Taeniopteryx* and *Allocaonia* were mating, feeding, and flying at Oakwood, but two days later at the same place and same time of day, with an air temperature of 37° F., their activity was greatly diminished, particularly in the case of the large *Taeniopteryx*. Complete cessation of activity of the adults of *Allocaonia*, however, is not brought about by freezing temperatures. I have seen adults of *A. recta* and *A. vivipara* at Oakwood crawling about on masses of frozen leaves in the stream and on the ice and snow when the air temperature was as low as 20° F. During the coldest days of the winter the adults take refuge under flat stones near the water's edge, under leaves, under the bark of trees, and beneath other objects which will provide them with a certain amount of shelter. Sometimes the rapid alternation of warm and cold days leads to their undoing. Enticed from protecting shelters by comparatively warm days, they may be caught by the sudden return of very cold and freezing weather. As a result, it is no uncommon sight to see adults of *Allocaonia* frozen tightly in the ice which at times covers the small brooks in this region.

Another feature of the life of the fall and winter stoneflies is the evident proterandry already mentioned. When it is recalled that the males mate with the females very soon after the emergence of the latter, the necessity of this arrangement in the program of stonefly activity is apparent.

The length of life of the adults no doubt varies with the species, time of year, and character of the climate. In marked contrast with certain other aquatic insects—the mayflies, for example, which are often referred to as insects “living but a day”—the fall and winter stoneflies are capable of living for several weeks. Adult males and females of *A. mystica* of unknown age at time of capture have lived over two weeks in the laboratory in cages devised for the observation of egg-laying habits; and certain females of *A. vivipara*, captured within a few hours of their transformation from nymph to imago, have lived in similar cages under rather stimulating temperatures for more than three weeks. Under natural conditions, when periods of cold weather intervene to reduce their rate of metabolism, there is no reason why some females should not live for more

than a month. Although the data are inconclusive, because of lack of definite information concerning the age of males at time of collection, it appears that the males do not live as long as the females; at least, they died as a group sooner than females under exactly the same conditions.

REARING

The rearing of fall and winter stoneflies could be made a complicated and prolonged bit of experimentation, but for the immediate purposes simple methods have sufficed. It has been an easy matter to collect full-grown nymphs of all the species occurring in the Oakwood region and to keep them alive in small tins containing moist leaves, until the emergence of the adults. A surprising number can be reared in this manner, and the cast nymphal skins preserved for study and comparison with the adults. The same simple technique was employed in rearing adults from nymphs collected in other parts of the state. Such a procedure, of course, would not suffice for the exact determination of the number of instars of each species. In order to closely observe the feeding, mating, and egg-laying habits, the adults can be kept alive and healthy in small hermetically sealed aquarium jars containing a layer of moist sand, a supply of bark bearing a good growth of green algae, and old leaves and stems on which the adults may run around or in which they may hide or rest. The eggs of the fall and winter stoneflies will hatch in glass tubes covered at both ends with fine silk bolting and submerged in unpolluted streams (see p. 368); and no doubt if supplied with the proper quality and quantity of food, the nymphs will develop under the same conditions.

Habits of the Nymphs

FEEDING

The feeding habits of stonefly nymphs have been little known, or misunderstood. As a group they were long regarded erroneously as essentially carnivorous. Rousseau (1921) said of them: "Toutes ces larves, comme le démontre d'ailleurs le système broyeur de leur appareil buccal sont exclusivement carnassières; les jeunes larvules s'attaquent aux Infusoires, Oligochètes et petits insectes aquatiques adaptés à leur taille; plus grandes, elles dévorent les larves d'Ephémères, d'Agrionides, de Trichoptères, etc., même les larves plus jeunes de leur propre espèce." In both Europe and America this concept of the feeding habits of the nymphs has been undergoing a marked change during the last few years. Mertens (1923) and Schoenemund (1925) in Germany have shown that with the exception of some of the large nymphs of the family Perlidae most small stonefly nymphs are herbivorous and that their food consists of decaying vegetable matter, algae, and diatoms. In America, *Nemoura vallicularia* Wu (a species known only from the eastern states) was found by Wu (1923) to be entirely herbivorous; and Needham and Claassen (1925) added that "stoneflies have usually been considered as carnivorous.

but the examination of stomach contents of a number of nymphs indicates that *Pteronarcys*, *Nemoura* and others feed upon vegetable matter only, while *Perla*, *Acroncuria*, etc., prey upon animal forms as well as feeding upon vegetable material." These statements are sufficient to show that past ideas of the part played by stonefly nymphs, as an aggregate, in the biology of river systems are no longer tenable.

A careful study of the food habits of six species of fall and winter stoneflies in the Oakwood region (*S. fasciata*, *T. nivalis*, *A. vivipara*, *A. recta*, *A. mystica*, and *A. granulata*) has demonstrated that these species are essentially herbivorous, the bulk of their food consisting of fragments of decaying leaves, various diatoms, and a few protozoans. Three habitats (Stations I, II, and III) were studied from the angle of possible food occurring there, and samples of the microorganisms living in them were taken on March 5, 1927. Full-grown nymphs were also collected there at the same time, and their stomachs were found to contain fragments of decaying leaves and the following diatoms:

<i>Taeniopteryx nivalis</i> and <i>Strophopteryx fasciata</i> (Station I.)	<i>Allocapnia granulata</i> (Station II)
<i>Gomphonema olivaceum</i> (Lyngb.)	<i>Gomphonema olivaceum</i> (Lyngb.)
<i>Synedra ulna</i> (Nitz.)	<i>Synedra ulna</i> (Nitz.)
<i>Homoeocladia acicularis</i> (Kütz.)	<i>Homoeocladia</i> sp.
<i>Homoeocladia sigmoidea</i> (Nitz.)	<i>Allocapnia vivipara</i> (Station III)
<i>Fragilaria crotonensis</i> (Edw.)	<i>Gomphonema olivaceum</i> (Lyngb.)
<i>Lysigonium varians</i> (Ag.)	<i>Synedra ulna</i> (Nitz.)
<i>Cocconeis</i> sp.	<i>Navicula</i> sp.

In order to find out if the food of the young nymphs was different from that of the older nymphs, the stomach contents of some very small nymphs of *Allocapnia* and *Taeniopteryx* collected in October, 1928, were analyzed, with the following results:

<i>Taeniopteryx nivalis</i> (Station I)	<i>Allocapnia</i> sp. (Station I)
<i>Gomphonema olivaceum</i> (Lyngb.)	<i>Gomphonema acuminatum</i> Ehr.
<i>Gomphonema acuminatum</i> Ehr.	<i>Synedra ulna</i> (Nitz.)
<i>Synedra ulna</i> (Nitz.)	<i>Navicula</i> sp.
<i>Lysigonium varians</i> (Ag.)	<i>Amphora</i> sp.
<i>Diatoma vulgare</i> Bory.	<i>Cyclotella</i> sp.
<i>Cocconeis placentula</i> Ehr.	
<i>Amphora</i> sp.	
<i>Navicula</i> sp.	
<i>Gyrosigma</i> sp.	
<i>Cyclotella</i> sp.	

The above records of the food of the nymphs of *Taeniopteryx* and *Allocapnia*, both young and nearly full-grown, are sufficient to demonstrate the similarity in feeding habits of nymphs of various ages and the

herbivorous habits of the nymphs belonging to these two genera. No doubt a few protozoans are occasionally taken into the alimentary tract along with the diatoms, but the yellow fresh-water diatoms and decaying vegetation constitute their main food. Old leaves which have fallen into the water apparently supply the bulk of decaying vegetable matter used by the nymphs for food. Streams where *Allocapnia* or *Taeniopteryx* are abundant are always full of such decaying leaves, many of them as completely skeletonized as those fed upon by *Nemoura vallicularia* and illustrated by Wu (1923, Figure 127). Whether the great extent of the skeletonization of old leaves in the small streams of the Oakwood region is entirely due to nymphs of fall and winter stoneflies is questionable.

Although no nymphs of *Leuctra claasseni* have been critically studied from the standpoint of their food, a superficial examination of one nymph revealed the presence of decaying vegetation. It appears, therefore, that all of the fall and winter stoneflies of Illinois are herbivorous.

EMERGENCE

When the nymphs of *Taeniopteryx*, *Strophoteryx*, and *Allocapnia* reach their full development and are ready to shed their last nymphal skin, they crawl out of the water on stones, sticks, leaves, or any other objects which protrude above its surface. After leaving the water they usually travel but a few inches from it, then come to rest, securely fasten their tarsal claws so that they will not become dislodged, and prepare for their last moult. In order that the adults may issue, the chitinous nymphal skin splits along the mid-dorsal line of the body, beginning at the epicranial arms and extending backward as far as the first abdominal segment (Figure 11). Freed from the nymphal skin the adults are at first soft and flabby and incapable of flight, but in the course of a short time the wings become dry and completely expanded, the body and legs become firm and the chitinous parts of the body assume their normal dark and light colors.

By finding the cast skins of the full-grown nymphs, many of which can be named to species, it is sometimes possible to secure distributional records for certain localities when the adults for some reason or other cannot be found. If there is a considerable lowering of the water level in a river after the emergence of the adults, the nymphal skins may be found on tree trunks six or eight feet above the low water level.

DEVELOPMENT

Practically no information has been published by other investigators regarding the hatching time of the eggs of fall or winter stoneflies. With this in mind a few observations and experiments have been made by the writer regarding this matter. In spite of intensive collections and careful observations aimed to determine this particular point in their biology, I have never found the nymphs of *Taeniopteryx*, *Strophoteryx*, or *Allocapnia* under natural conditions before October 10. In view of the fact that all nymphs found in October in the Oakwood region are minute or

very small, it might be assumed that they do not emerge from the eggs until after the summer season has passed and the water has become cold. This, however, is not the case.

In February, 1928, I placed an egg mass of a female of *T. nivalis* in a small vial, closed the open end by tying a piece of linen cloth over it, and then placed it in the water at Station IV. This vial was not examined again until May 22 and then was found to contain very small nymphs which apparently had died from lack of nourishment. A similar experiment was tried in December, 1928, with two egg masses of *A. recta* in a glass tube covered at both ends with several layers of cheese cloth to permit a free circulation of water. When one of these tubes (the other was washed away by the current) was next examined, on January 10, 1929, no trace of eggs or nymphs could be found; probably they had escaped through the meshes of the cheese cloth. This same day the experiment was repeated with an egg mass of *A. vivipara*, but fine silk bolting was used to cover the open ends of the glass tube. When next examined on January 29, the tube was found to contain some small live nymphs of *vivipara* as well as some eggs in good condition about ready to hatch (breaking them released live nymphs) and some eggs killed by a fungous growth. These experiments are sufficient to prove that the eggs of *Taeniopteryx* and *Allocapnia* hatch before the water becomes very warm. Evidently, then, the nymphs of these fall and winter stoneflies make little advance in their development during the warm season and remain so small that they have been overlooked by all investigators. Since the first instar nymphs are delicate creatures not capable of surviving a drying process, it is a safe assumption that the species inhabiting very small streams, which are reduced to pools in dry weather, must congregate in the bottom of the pools or in moist places in the stream bed.

The number of instars during the life of the nymphs of the fall and winter stoneflies was not determined, but because of the fact that nymphs under observation frequently molt and that many preserved nymphs of various sizes show evidences of being nearly ready to molt when collected, I surmise that there are many instars. Wu (1923) has shown that *Nemoura vallicularia* Wu, the adults of which appear in spring, has over twenty instars. It is doubtful whether the fall and winter species of Illinois have as many as this, because the rapid developmental period of the nymphs is restricted to fewer months.

MOVEMENTS

Although no positive information was gathered concerning the territory traversed by the nymphs, it seems likely because of their habitat preferences that most of their existence is spent within a limited area. By high water, however, many are dislodged and swept away from places where they would remain under ordinary circumstances. This explains the occasional presence of nymphs of *Taeniopteryx* and *Strophopteryx* in Station II in the Oakwood region. By the same process other nymphs are washed out of the small brooks into the larger streams.

Attention may be called at this place to the peculiar movements of the fall and winter stonefly nymphs, which are suggestive of the walking gait of many reptiles such as lizards and alligators. Their gait is usually slow, accompanied by a right and left lashing of the abdomen and tail-like cerci, which drag along behind. Although they are not alone among the aquatic insects in this peculiar style of locomotion, it aids the collector in recognizing the smaller nymphs upon stones, leaves, and other objects under the water.

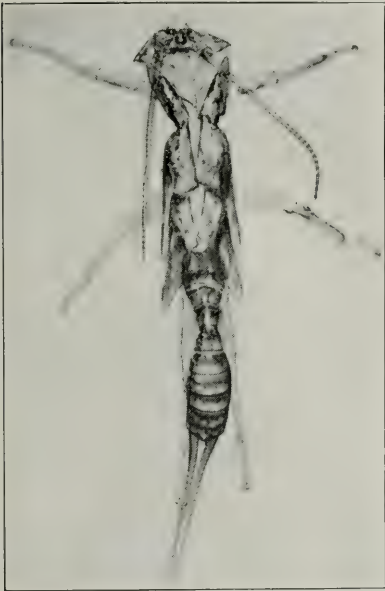


Fig. 11. Dorsal view of cast nymphal skin of female of *Strophopteryx fasciata* (Burmeister).



Fig. 12. Adult female of *Allocapnia granulata* (Claassen) with wings clipped to show attachment of mites.

Enemies

The fall and winter stonefly nymphs of Illinois seem to be remarkably free in their later stages from the attacks of predacious or parasitic enemies. This is no doubt due to the time of the year when their growth is most rapid, as well as to the character of the streams they inhabit, their size, etc. The fact that their greatest development comes at a time of year when fishes feed little, or not at all, certainly is one saving factor, and perhaps this explains why the winter stoneflies appear in enormous numbers although the summer forms are seldom abundant. Yet, since each female lays hundred of eggs, many of the eggs or the early instar nymphs must meet death by various undetermined means; otherwise even larger numbers of adults would be found. Since certain large stonefly

nymphs and other aquatic insects occupying the same habitats are definitely known to be carnivorous, it is reasonable to suppose that they eat small nymphs of the species which we are considering. No true parasites were found attacking any of the thousands of nymphs examined—an indication that they are very rare if not altogether lacking. Interesting to find, but of little importance in effect, is the fact that growths of Infusoria, such as *Opercularia*, occur on many nymphs.

The adults are directly attacked by the immature forms of a water mite (*Diplodontus* sp., det. Ruth Marshall) whose biological history is not well known. I have found these small red mites on various species of *Allocapnia* from December to the middle of March, but never on *Taeniopteryx* or *Strophopteryx*. The mites attach themselves to the adults, preferably on the dorsum of the abdomen beneath the wings (Figure 12), and may cause small scars. Rarely are they abundant enough to interfere seriously with the normal activities of their host, and only occasionally have enough of them been found on a single adult to reduce its vitality or hamper its movements. How they get on the adults in the first place, as well as what becomes of them when the insects die, is still a mystery.

Although I have never seen birds eating stoneflies in winter nor found any such records in literature, I see no good reason why the adults should not be choice tid-bits in the diet of certain of our winter residents. In fact, because of the abundance of these insects and their appearance on trees at various times during winter, it seems that if they are not eaten a rich supply of food is being overlooked by our feathered friends.

TAXONOMY AND NOMENCLATURE

While accumulating a collection of the fall and winter stoneflies of Illinois, consisting of some seven thousand specimens of adults and nymphs, the writer made particular efforts to collect mating pairs. As a result, mating pairs of the following species were taken: *Taeniopteryx nivalis* (Fitch), *Taeniopteryx parvula* Banks, *Strophopteryx fasciata* (Burmeister), *Allocapnia granulata* (Claassen), *Allocapnia pygmaea* (Burmeister), *Allocapnia vivipara* (Claassen), *Allocapnia recta* (Claassen) and *Allocapnia mystica* Frison. In addition, certain females of *Allocapnia* have been found in association with males of *Allocapnia forbesi* Frison under circumstances which leave no doubt as to their specific identity. The possession of these properly associated males and females has given a sound basis for the recognition of the specific characters of the females found in Illinois and for the preparation of keys for both males and females. The males, except for the two new species described in this paper, have been previously keyed to species by Needham and Claassen (1925), but as far as I am aware no attempt ever has been made to key the females.

Probably because of the difficulty of properly associating the nymphs with the adults, little has been known about the immature stages of the North American plecopteran fauna, and even the genera have not been adequately characterized. In this respect we are not exactly alone, for in Europe where the plecopteran nymphs have been better studied, less than one-third of them (Koponen, 1917) have been associated with their adults. Perhaps the most thoroughly investigated region in the world in regard to its stonefly nymphs is in northwestern Germany where Schoenemund (1925) has been able to associate some thirty-eight nymphs with adults of a total stonefly fauna numbering about fifty species. As the basis for the recognition and keying of the nymphs of the fall and winter stoneflies of Illinois, none of which have been previously characterized, collections were made of them at every opportunity. From time to time, too, particularly in the Oakwood region, mature nymphs have been collected and the adults reared from them.

Such rearings and collections have served to remove all doubts regarding the correct generic association of the nymphs with their adults and, with the exception of the genus *Allocapnia*, for the species as well. The difficulty with the nymphs of *Allocapnia* is due to the fact that this genus affords an exceptionally good example of a homogeneous group. Specific differences in the adults of this group are well marked and constant, but they consist for the most part of genital or accessory genital characters which are not developed in the nymphs in a comparable manner. There are, however, certain characters which permit the ready separation of all nymphs of this genus into males and females and the identification and keying of several of the males. Although it is possible for one well acquainted with the adults and nymphs of *Allocapnia* from Illinois to name most of the remaining species not included in the key (because of knowledge of the seasonal and geographical distribution of the species in the state, streams where certain species are liable to be found, slight indications of structural characters later apparent in the adults, etc.), it is impossible to formulate a key which would not at times be misleading to others. Therefore, instead of constructing a key based upon exceptional specimens of full-grown nymphs, in which structural characters of adults can be plainly deciphered in advance, attention is called to such specimens under each species of *Allocapnia*. The chances of naming the nymphs of this genus, particularly the females, increase with the age of the specimens, and *vice versa*. Many of the full-grown female nymphs of *Allocapnia* show in clear outlines what the ventral structure of the eighth abdominal segment of the adult will be (Figure 40), while others of similar size, due to a lack of contrasting chitinization at time of capture, show nothing (Figure 39). In the males, also, a heavily chitinized knob-like structure may be frequently seen beneath the dorsal integument of the ninth abdominal segment, and in exceptional cases it is so well delineated that the species can be recognized by it.

TAENIOPTERYX PICTET (*sensu str.*)

Taeniopteryx Pictet, Histoire Naturelle générale et particulière des Insectes Neuroptères. Première Monographie : Famille des Perlides, 1841-1842, p. 345.

Genotype *Taeniopteryx nebulosa* L. by original designation.

Nephelopteryx Klapalek, Termeszetrájsi Füzetek, Vol. XXV, 1902, p. 179.

Genotype *Nephelopteryx nebulosa* L. by original designation.

Nephelopteryx Needham and Claassen, Monograph of the Plecoptera or Stoneflies of America North of Mexico. Thomas Say Foundation of Ent. Soc. Amer., Vol. II, 1925, p. 288.

In 1902, Klapalek recognized certain groups of European stoneflies as genera (*Taeniopteryx*, *Rhabdiopteryx*, *Oemopteryx*, and *Nephelopteryx*) which were formerly assigned to a single genus (*Taeniopteryx* Pictet). In our latest American monograph of Plecoptera, by Needham and Claassen (1925), these groups are recognized only as subgenera, but in view of the marked and fundamental differences existing between them, particularly the nymphs, it seems advisable to the writer to consider at least the two groups represented in Illinois as valid genera. Needham and Claassen (1925) following Klapalek (1902) considered *Taeniopteryx trifasciata* Pictet (European) as the genotype of *Taeniopteryx* Pictet (*sensu lat.*); and the same, although in a restricted sense, has been done by Schoenemund (1928). This was in error, however, because Pictet (1841) when erecting *Taeniopteryx* designated *Nemoura nebulosa* L. as its type in the following language: "Je connais six espèces de ce sous-genre, dont le type est la *Nemoura nebulosa* des auteurs." Although it is true, as Albarda (1889) states, that Pictet in 1832 did not know the true *nebulosa* L., he later corrected his mistake, so that his reference to *nebulosa* L. in 1841-1842 was not a misidentification. Very recently a brief note correcting the wrong citation of *trifasciata* as the genotype has been published by Claassen (1928), but no mention is made of the nomenclatorial changes it necessitates.

This erroneous conception of the genotype of *Taeniopteryx* (*sensu lat.*) has led to the wrong taxonomic assignment of the generic name *Taeniopteryx*, when either the various related groups were considered as separate genera (Klapalek) or as subgenera (Needham and Claassen). The studies of various European investigators (Reuter, 1904; Lauterborn, 1903; and Lestage, 1920) have shown that the nymph of *nebulosa* L. has tracheal coxal appendages. Klapalek erected a new genus—*Nephelopteryx*—for *nebulosa* and related forms in 1902, and Needham and Claassen (1925) have correctly placed, though as a subgenus, *nivalis*, *maura*, and *parvula* in this complex. Since *nebulosa*, however, is the type of the genus *Taeniopteryx* by original designation of its author, it follows according to Article 29 of the International-Rules of Zoological Nomenclature that the name *Taeniopteryx* be used for the complex containing *nebulosa* and closely related species. In America, these closely related species are *nivalis*, *parvula* and *maura*. Accordingly, in this paper the generic name of *Taeniopteryx* is used for the Illinois species, *nivalis* and *parvula*, species shown by my studies to have tracheal coxal appendages in the nymphs as do the nymphs of the European genotype, *nebulosa* L.

BRACHYPTERA NEWPORT

Brachyptera Newport. On the Anatomy and Affinities of *Pteronarcys regalis* Newm.: with a Postscript, containing Descriptions of some American Perlidae, together with Notes on their Habits. Transactions of the Linnean Society of London, Vol. XX, Part III, 1851, p. 451.

Taeniopteryx Klapalek (*sensu str.*), Termeszetrájsi Füzetek, Vol. XXV, 1902, p. 178. Genotype *Taeniopteryx trifasciata* by designation of Klapalek.

The transfer of the older name *Taeniopteryx* (1841-1842) to the genus *Nephopteryx* Klapalek (1902) containing *nebulosa* L., *araneoides* Klp., and *schoenemundi* Mert. necessitates the use of another generic name for the taxonomic group containing the species *trifasciata* Pict., *braueri* Klp., *kempnyi* Klp., *risi* Mort., *seticornis* Klp., and *tristis* Klp. At first it was thought that a new name might be needed for this group, but Dr. Nathan Banks has kindly brought to my attention the name of *Brachyptera*, proposed as a subgeneric name for the European *trifasciata* Pictet and a new North American species, *glacialis*, by Newport in 1851. The fortunate original inclusion of *trifasciata* in *Brachyptera* by Newport permits the definite recognition of this genus and the use of this name for those European forms previously called *Taeniopteryx* Klapalek (*sensu str.*). Since to my knowledge no type of *Brachyptera* has ever been designated, *trifasciata* Pictet becomes its type by designation of Klapalek in 1902 (Article 30, International Rules of Zoological Nomenclature). Because *glacialis* has remained unrecognized, it is indeed a most fortunate circumstance that it, one of the two species originally included by Newport in *Brachyptera*, has become excluded as a genotype because of the designation by Klapalek. If eventually there is found an American brachypterous male which can be considered as *glacialis* Newport, it should be placed in this genus, providing it has a two- or three-branched cubital vein. Since no known American species of *Taeniopteryx* in its broadest sense (Taeniopterygidae of European authors) have been described as having such a vein, no American species can at present be rightfully assigned to this genus.

TAENIONEMA BANKS

Taenionema Banks, Psyche, Vol. XII, June-August, 1905, pp. 56-57. ♂.

Genotype *Taenionema analis* Banks = *T. pacifica* Banks by original designation and monobasic.

Taeniopteryx Needham and Claassen (*sensu str.*), Monograph of the Plecoptera or Stoneflies of America North of Mexico. Thomas Say Foundation of Ent. Soc. Amer., Vol. II, 1925, p. 288.

The North American species *nigripennis* Banks, *pacifica* Banks, *californica* Banks, *grinnelli* Banks, *pallida* Banks, and *banksii* Needham and Claassen were assigned by Needham and Claassen (1925) to *Taeniopteryx* (sense of Klapalek, 1902); but since they cannot properly be placed there for the reason already mentioned (lack of two- or three-branched cubital veins), they must be associated with another generic or subgeneric name. Fortunately, the generic name of *Taenionema* Banks (1905) is available for this complex. According to Newcomer (1918), the full-grown nymphs of *pacifica* have no tracheal appendages—a condition which should hold good for all of the species included here if the group is a natural one.

STROPHOPTERYX new genus

Type *Strophopteryx* (*Semblis*) *fasciata* (Burmeister) original and present designation.

Rhabdiopteryx Banks, Catalogue of the Neuropteroid Insects (except Odonata) of the United States. Amer. Ent. Soc., Philadelphia, 1907, p. 14.

Rhabdiopteryx Needham and Claassen, Monograph of the Plecoptera or Stoneflies of America North of Mexico. Thomas Say Foundation of Ent. Soc. Amer., Vol. II, 1925, p. 288.

The erection of a new generic name for the complex containing the American species *fasciata* Burmeister seems necessary to the author. This species was placed by Banks (1907) in the genus *Rhabdiopteryx* Klapalek and by Needham and Claassen (1925) in the same group but reduced to subgeneric status. It seems to the writer, however, that *fasciata* contains just as many or more characters in common with the genus *Oemopteryx* Klp. and its species *locwii* Alb., as it has in common with *Rhabdiopteryx* and its species *neglecta* Alb. and *hamulata* Klp. Apparently the presence of an extra costal crossvein, and sometimes two, before the end of the subcosta in the forewing of *fasciata* has influenced the placing of *fasciata* in *Rhabdiopteryx*, which is stated to possess two or three such extra crossveins. *Oemopteryx* is stated and figured as having no extra crossveins, a condition sometimes occurring in specimens of *fasciata*. The fact that some specimens of *fasciata* do not have any extra crossveins is an indication that at least in the species *fasciata* the extra crossveins are not conclusive indications of generic relationships. In other words, in respect to extra costal crossveins some specimens would exactly fit *Rhabdiopteryx*, others *Oemopteryx*, and many fall half-way between. In regard to other structural details, such as the shape of the subgenital plate in the female and the longer anal cerci of the males, *fasciata* seems to fit in *Oemopteryx* better than in *Rhabdiopteryx*. The chief difficulty in placing *fasciata* in *Oemopteryx* lies in the fact that in *Oemopteryx* the subcosta ends about in the middle of the wing and in *fasciata* the subcosta continues to about two-thirds of the length of the wing. It seems to the writer that the best purposes of classification are to be served by the placing of *fasciata* Burmeister in a separate genus to which I assign the generic name of *Strophopteryx* and designate *fasciata* Burmeister as its type (present designation and also monobasic).

This genus may be separated from the other related genera by the following combination of characters: three ocelli; anal cerci of male with at least six segments; apex of subgenital plate of male bent upwards at right angle, subgenital plate in female greatly elongated and covering tenth ventral segment; usually one extra costal crossvein before the termination of the subcosta, but sometimes none; first branch of cubitus (Cu_1) with a single accessory vein in outer part of fore wing and therefore with only two branches; and a crossvein (possibly Sc_2) after termination of subcosta (Sc_1). Nymph without coxal appendages; glossa of labium (Figure 14) divided by a mesarima which extends as a suture about one-half way to the base of the ligula, and galea of maxillae (Figure 18) with dense patch of short setae at apex.

Keys to the Genera

ADULTS

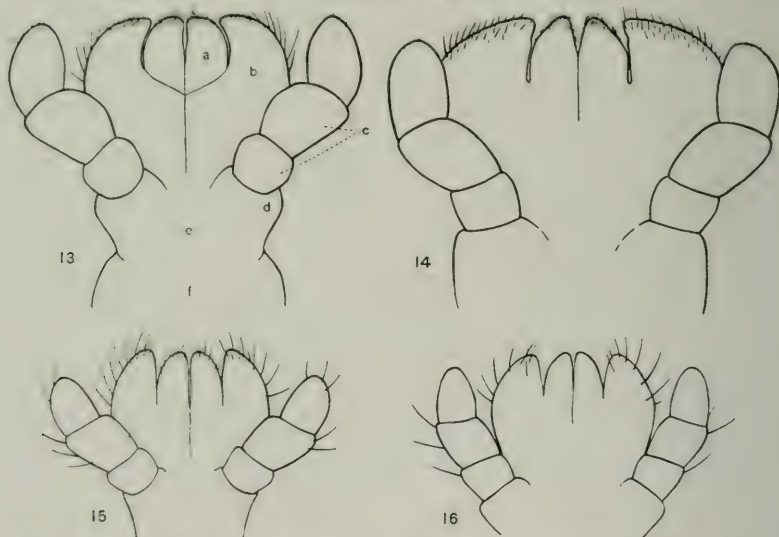
1. Abdominal cerci much reduced, less than nine-segmented, not extending backwards as far as one-half the length of the abdomen (Nemouridae)...2
- Abdominal cerci long, with more than nine segments, extending tail-like backwards at least one-half the length of the abdomen (Capniidae)...4
2. Second tarsal segment less than one-half as long as the first.....**Leuctra**
- Second tarsal segment more than one-half as long as the first.....3
3. Coxae with small round membranous areas (Figure 29) on ventral surfaces (point of articulation of tracheal appendages in nymphs); cerci of male reduced to a single globose segment; subgenital plate of male (prolongation of ninth ventral abdominal segment) with apical portion not abruptly turned upwards at a right angle; ninth abdominal sternite of female without a long triangular projection.....**Taeniopteryx**
- Coxae without membranous areas on ventral surfaces (Figure 30); cerci of male with at least three filiform segments; subgenital plate of male with apical portion turned abruptly upwards at a right angle; ninth abdominal sternite of female with a long triangular projection.....**Strophopteryx**
4. Mesosternum with posterior margin of large heavily or darkly chitinated medial area (mesobasisternite) strongly produced backwards (Figure 57); second transverse vein (subcosta) of fore wing uniting with margin of fore wing (costa) much before the cord (more or less transverse line-up of cross-veins and some longitudinal veins beyond middle of wing); anal field or lobe of hind wing large and nearly as long as front portion**Allocaupnia**
- Mesosternum with posterior margin of large heavily or darkly chitinated medial area (mesobasisternite) nearly transverse (Figure 56); second transverse vein of fore wing extending to or nearly to the cord; anal field of hind wing reduced and not extending much beyond half of length of front portion**Capnia**

NYMPHS

1. Second tarsal segment (Figures 25 and 26) approximately as long or longer than the first; somewhat robust in general habitus; coxae with or without tracheal appendages2
- Second tarsal segment (Figures 27 and 28) much reduced, not as long as the first; more cylindrical or filiform in general habitus; coxae never with tracheal appendages3
2. Coxae with conspicuous tracheal appendages (Figures 25 and 41); ninth abdominal sternite not produced backward with a V-shaped projection covering part of tenth segment.....**Taeniopteryx**
- Coxae without tracheal appendages (Figure 26); ninth abdominal sternite conspicuously produced backwards with a V-shaped projection (Figures 42 and 43) covering part of tenth segment.....**Strophopteryx**
3. Lateral margins of abdominal segments somewhat rounded, segments widest at posterior margin and narrower towards base; glossa of labium (Figure 15) divided by an incision which extends longitudinally as a suture nearly to base of ligula; wing pads (Figure 35), with one exception (Figure 33), present in medium to large size nymphs; hind wing pad with anal lobe or area extending far beyond middle of wing, about one-half as long as wide; last abdominal segment (Figure 33) with a conical projection in the male; legs (Figure 27) with numerous short setae and long slender ones; venation of fore wing pad, where distin-

guishable, without numerous cross-veins between medio-cubital longitudinal veins *Allocapnia*

Lateral margins of abdominal segments almost straight, abdomen appearing cylindrical in shape; glossa of labium (Figure 16) divided by an incision which extends as a suture less than one-half length of ligula; wing pads always present in medium to large nymphs; hind wing pad with anal lobe or area not extending much beyond middle of wing, about three times as long as wide; last abdominal segment without conical projection; legs (Figure 28) with only a few short setae or long slender ones; venation of fore wing pad, where distinguishable, with numerous cross-veins between medio-cubital longitudinal veins *Leuctra*



Figs. 13-16. Labia of nymphal males: 13, *Taeniopteryx nivalis* (Fitch); 14, *Strophopteryx fasciata* (Burmeister); 15, *Allocapnia vivipara* (Claassen); 16, *Leuctra claasseni* Frison. a, glossa; b, paraglossa; c, labial palpus; d, palpiger; e, mentum; f, submentum.

Keys to the Species, with Descriptions of New Species and Nymphs

TAENIOPTERYX PICTET

Histoire Naturelle générale et particulière der Insectes Neuroptères.

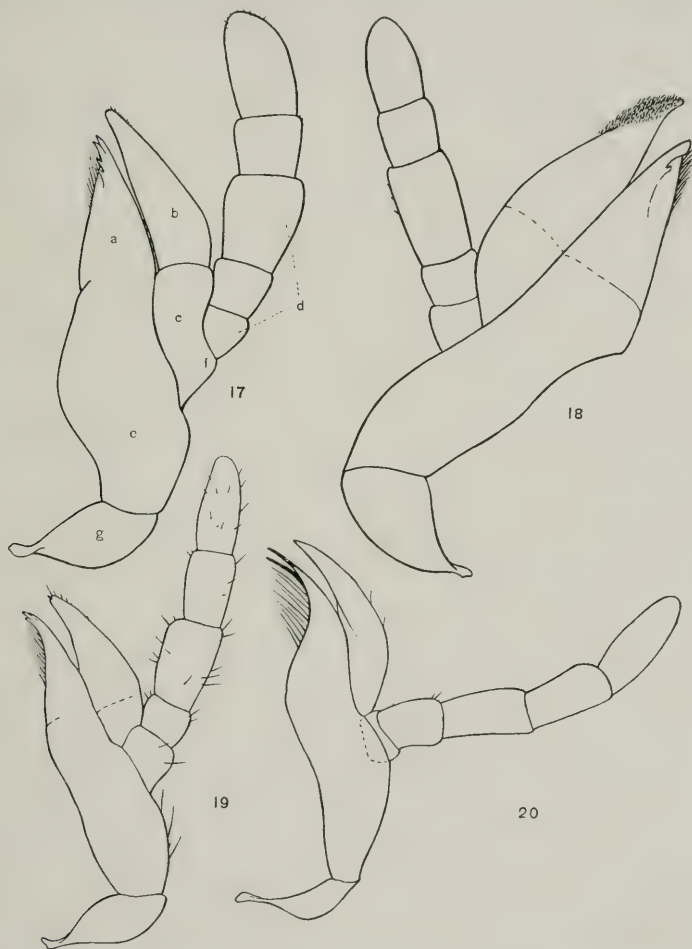
Première Monographie : Famille des Perlides, 1841-1842, p. 345.

Genotype *Taeniopteryx nebulosa* by original designation.

The adult males of the Illinois species of this genus have been previously keyed, along with other species, by Needham and Claassen (1925), but the females have not received a similar treatment. The capture of mating pairs of both Illinois species belonging to this genus has insured the correct association of the two sexes and enabled the formation of keys distinguishing both sexes. Likewise, the rearing of adults from full-grown nymphs has established beyond doubt the correct association of the nymphs with their adults and their sexual differences.

ADULTS

- Male with a globular appendage on ninth abdominal sternite (subgenital plate); female with portion of eighth abdominal sternite (Figure 76) anterior to genital opening darkly chitinized.....**nivalis** (Fitch)
- Male without a globular appendage on ninth abdominal sternite; female with portion of eighth abdominal sternite (Figure 77) anterior to genital opening not darkly chitinized, at most with anterior border of genital opening dark colored, contrasting with membranous area.....**parvula** Banks



Figs. 17-20. Maxillae of nymphal males: 17, *Taeniopteryx nivalis* (Fitch); 18, *Strophopteryx fasciata* (Burmeister); 19, *Allocapnia vivipara* (Claassen); 20, *Leuctra claasseni* Frison. a, lacinia; b, galea; c, subgalea; d, maxillary palpus; e, stipes; f, palpifer; g, cardo.

NYMPHS

Males and females with a conspicuous white mid-dorsal stripe (Figures 32 and 59) extending from head to end of abdomen; apex of abdomen seen from the side in the male (Figure 62) with supra-anal lobe protruding much above apical segment, not so in female; mature nymphal male with outline of globular appendage visible near middle of ninth sternite *nivalis* (Fitch)

Males and females without a conspicuous white mid-dorsal stripe extending from head to end of abdomen; apex of abdomen seen from the side in the male with supra-anal lobe protruding much above apical segment, not so in female; mature nymphal male without outline of appendage visible near middle of ninth sternite.....*parvula* Banks



Figs. 21-24. Mandibles of nymphal males (ventral view): 21, *Taeniopteryx nivalis* (Fitch); 22, *Strophopteryx fasciata* (Burmeister); 23, *Allocapnia vivipara* (Claassen); 24, *Leuctra claasseni* Frison. a, right mandible; b, left mandible.

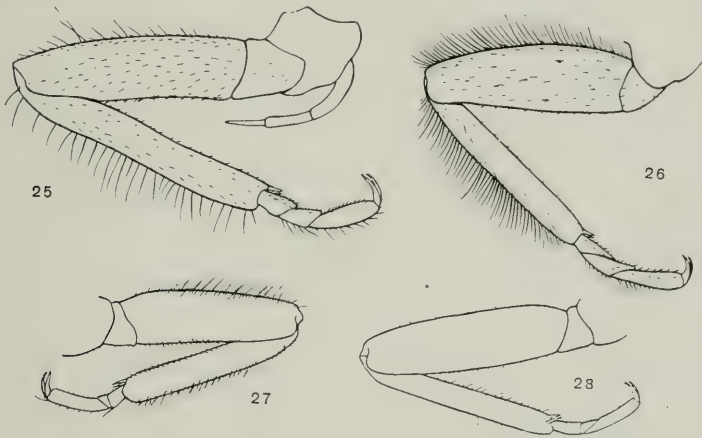
TAENIOPTERYX NIVALIS (FITCH)

Amer. Journ. Agr. Sci., Vol. V, May, 1847, p. 279, ♂ ♀.

This species, generally distributed throughout the eastern states from Maine to North Carolina and once previously recorded from Illinois by Needham and Claassen (1925), is one of two of the most abundant species of winter stoneflies in Illinois. Of the two most abundant species it is the largest and therefore the most conspicuous and most frequently seen member of our winter fauna.

The male and female have been previously well characterized by Needham and Claassen (1925). In addition to their diagnosis of this species, it should be noted that the adult females almost invariably have the area anterior to the genital opening on the ninth abdominal sternite (Figure 76) very heavily and darkly chitinized. This sometimes makes it appear as though the genital opening was at the very hind margin of the ninth sternite when it is in reality merely in the posterior more membranous or light-colored portion.

The study of thousands of specimens of this species has shown that there exists considerable variation in shape of the hind femora (Figures 64 and 65) of the male. This was particularly evident in specimens from the Oakwood region, where some males of *nivalis* were found which showed a small tooth-like projection very strongly developed. In one case, even, a male was found with a pronounced tooth upon the tibia instead of upon the femur—an indication of the instability of this character. In the Oakwood region about one adult male out of twenty showed a tendency for the hind femora to be toothed. As one might expect from what has just been stated, male nymphs were also found in the Oakwood region which showed a rudimentary development of a tooth-like projection on the hind femora.



Figs. 25-28. Hind legs of nymphal males: 25, *Taeniopteryx nivalis* (Fitch); 26, *Strophopteryx fasciata* (Burmeister); 27, *Allocapnia vivipara* (Claassen); 28, *Leuctra claasseni* Frison.

The presence of this tooth-like projection on adults positively identifiable as *nivalis* casts some suspicion on the specific distinctiveness of *T. maura* Pictet (1842) and *T. nivalis* (Fitch, 1847). *T. maura* is at present separated only in the male sex from *nivalis* on the basis of its tooth-like projection on the hind femora and its absence in *T. nivalis*. That this is not a positive character for differentiating *maura* is shown by its presence and variability on numerous males of the form now called *nivalis*. Through the kindness of Professor Claassen, specimens of *maura* from Plummer's Island, Maryland, were sent to me for examination. In these specimens the tooth-like projection is more strongly developed than on any specimens of *nivalis* found in the Oakwood region, but it is essentially of the same character. Since other positive characters for the differentiation of the species of *maura* and *nivalis* have not been located, and their range coincides, it is likely that *nivalis* and *maura* are the same

species. If this is later found to be the case, *maura* Pictet must stand as the name of the species here listed as *nivalis* (Fitch), because the name *maura* has priority. *Nivalis* will still be available, however, as a varietal or subspecific name for the specimens without a tooth-like projection on the hind femora of the males. The rearing of nymphs and biological studies of specimens of the typical *maura* in states where *maura* is the abundant form should lead to the final solution of the problem.

That the nymphs will be fundamentally similar to *nivalis* is predictable, because the adults of *maura* sent to me for study show the characteristic scar (round membranous area) on coxae where tracheal gills were attached in the nymphs. As far as I am aware, this character of adults belonging to this group of stoneflies has not been previously mentioned in our American literature, but it is of great importance. The presence of these membranous scars on the coxae of adults belonging to *Taeniopteryx* (*sensu str.*) is a reliable indicator of the presence of coxal tracheal appendages in the nymphs, and *vice versa*. After finding these scars on the coxae of adults of *nivalis*, a search through the literature of my subject revealed that Lauterborn (1903) had previously reported that the adult of *nebulosa* of Europe shows "an derselben Stelle, wo sie die Larve aufwies, die Tracheenkiemen ganz deutlich hervor, vielleicht etwas kleiner als bei der Larve, aber sonst in Structur etc. den larvalen Kiemen völlig gleich," and that in the older adults "sie [Tracheenkiemen] erscheinen dann an feucht conservierten Thieren als kleine weichhäutige Höckerchen von weiszlicher Farbe, an getrockneten Exemplaren dagegen zum mindesten als helle Flecke auf dunklerem Untergrund." Aside from the confirmatory observation of Lestage (1920), no further mention or use of this character in the adults has been made.

The discovery that a species of *Taeniopteryx* in the nymphal stage possessed coxal tracheal appendages—a new type of tracheal appendage in aquatic insects—was apparently first reported by Klapalek (1900) and shortly thereafter in America by Needham (1901). There is no doubt that these coxal tracheal appendages have a true respiratory function, since they are directly connected with the tracheal system as Lauterborn (1903) has shown and as I have determined by dissections.

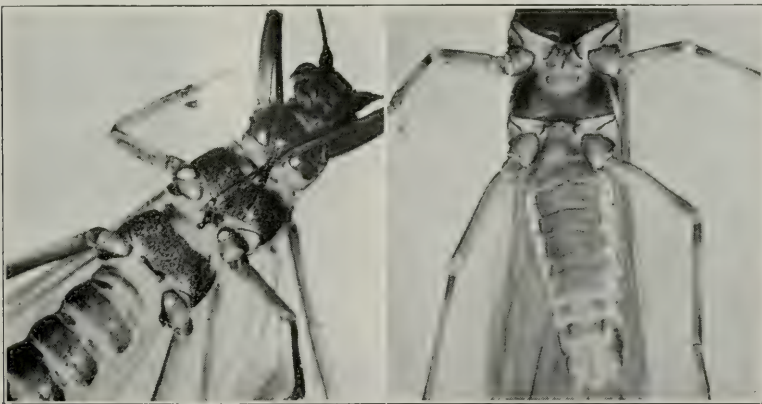
Adults of this species have been found at the following localities in Illinois: Algonquin, Barstow, Carmi, Castle Rock, Chicago, Chrisman, Como, Danville, Dixon, Elizabethtown, Elmwood, Georgetown, Golconda, Grayville, Hamlet, Havana, Homer, Humboldt, Kankakee, Lawrenceville, Lexington, Louisville, Mackinaw, Mahomet, MacQuon, Marengo, Mascoutah, Muncie, Monmouth, New Athens, New Memphis, Norwood, Oakwood, Ocoya, Paris, Pekin, Peoria, Pontiac, Rockford, Seymour, St. Joseph, Towanda, Union Hill, Urbana, Walnut Prairie, and White Heath. The earliest record for the appearance of an adult is January 2 at Muncie and Oakwood, and the latest record is April 21 at Havana.

The nymphs have been collected at the following localities: Danville, Elizabethtown, Grayville, Homer, Hutsonville, Muncie, New Memphis, Oakwood, Pekin, Peoria, and Rock Island. The small nymphs were first found on September 20 at Muncie and last found on April 12 at Pekin.

Since the nymphs have not before been definitely recognized and characterized, a description of both sexes based upon full-grown specimens is given.

Nymphal Male (Figures 32 and 41).—General color dark brown, with a dorsal medial light-colored strip extending from head to apex of abdomen; legs, mouth parts, and labrum somewhat lighter in color than body; apical two-thirds of antennae and anal cerci yellow-brown or white. General body form elongate and also robust, wing pads protruding at an angle from sides of body, rarely over 11 mm. in length exclusive of antennae and anal cerci. Head at compound eyes as wide as prothorax, rounded behind; epicranial stem as long as epicranial arm; developing ocelli arranged in a triangle, posterior ocelli situated on epicranial arms over twice as far apart as distance from one to compound eye, anterior ocellus situated forward on the front about one-half the distance between posterior ocelli; labrum somewhat perpendicular to plane of front. Antennae long and filiform, with nearly sixty or more segments; first segment about twice as wide as second segment and at least as long as second and third segments combined, basal segments wider than long, succeeding segments gradually becoming more elongate and with apical segments two or three times as long as wide, setae minute or lacking.

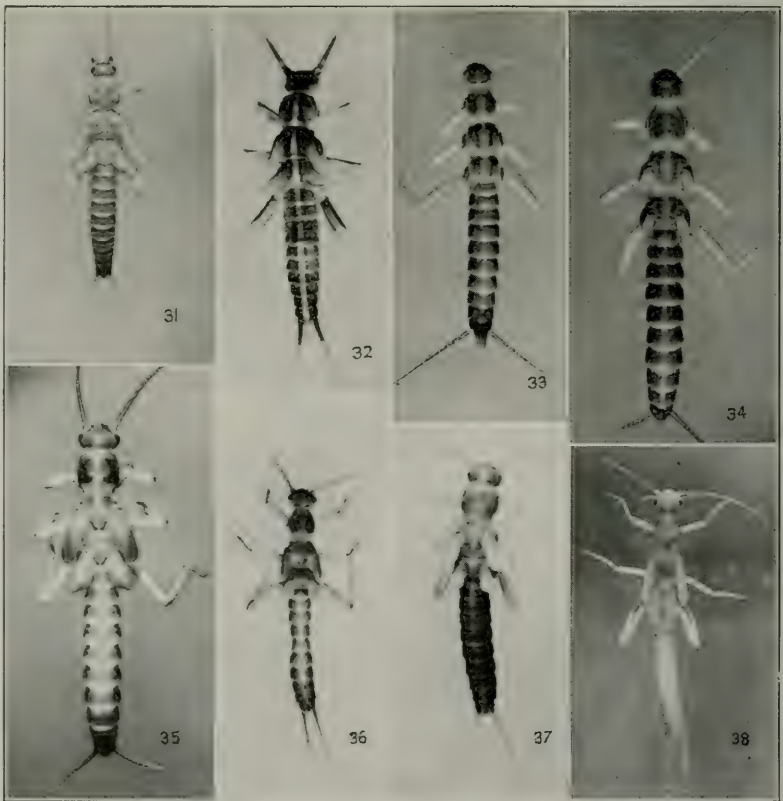
Labium (Figure 13) with glossa divided into two parts by an incision which extends longitudinally as a suture nearly to base of ligula, glossae with numerous short setae at apex and much smaller than the paraglossae; paraglossae broadly curved on outer margin, not extending beyond glossae, with some long setae near apex; palpiger evident but not appearing as segment of palpus; labial palpus three-segmented, basal segment much the shortest, second and third segments about subequal in length, second segment broader than third, the latter rounded at apex. Hypopharynx about as large as ligula, lobe-like, rounded at apex and extending little if any beyond glossae. Maxillae (Figure 17) well developed, lacinia with several claw-like teeth curved in



Figs. 29, 30. Ventral views of adult females: 29, *Tachiopteryx nivalis* (Fitch), showing scars on coxae where tracheal appendages were attached to nymph; 30, *Strophopteryx fasciata* (Burmeister) showing lack of scars on coxae (no tracheal appendages in nymph).

wards at apex, beneath which on inner side is a row of long stiff setae; galea extending but slightly beyond lacinia, curved and tapering almost to a point at apex, a few short setae at apex; palpifer inconspicuous; maxillary palpi five-segmented and not much longer than galea, first and second segments shortest and subequal, third and fifth segments longest and subequal, fourth segment shorter than fifth and longer than second, fifth rounded at apex. Mandibles (Figure 21) heavily chitinized, with several large teeth directed inwardly on apical half, beneath which on inner margin is a well developed mola.

Pronotum slightly broader than long, front and hind angles evenly rounded, longitudinal median pale strip one-seventh as wide as pronotum; meso- and metathorax with longitudinal median pale strip as on pronotum; ventral surfaces of thoracic segments along median area with conspicuous indications of points of invaginations of furcae; wing pads large (Figure 32); fore pair about



Figs. 31-38. Dorsal views of nymphs: 31, female of *Strophopteryx fasciata* (Burmeister); 32, male of *Taeniopteryx nivalis* (Fitch); 33, male of *Allocaenia vivipara* (Claassen); 34, female of *A. vivipara* (Claassen); 35, female of *A. granulata* (Claassen); 36, male of *A. recta* (Claassen); 37, female of *A. recta* (Claassen); 38, male of *Leuctra claasseni* Frison.

three times as long as broad, overlapping base of hind wing-pads and extending at a slight angle away from body; hind wing pads with anal lobe extending over two-thirds the length of wing, not twice as long as broad, extending at about a forty-five degree angle from sides of body. Legs (Figure 25) long, hind legs longest and extending to or beyond apex of abdomen, fore legs shortest, tibiae somewhat longer than femora but not as broad; with numerous short, stout setae on ventral surface and some long hair-like setae on dorsal surface; tarsi three-segmented, first and second segments subequal in length, the third segment at least as long as first and second segments combined and with two large simple claws at apex; tibiae with two short spines at apex; coxae of all legs with segmented, whitish, membranous tracheal appendages (Figure 41) appearing three-segmented when extended.

Dorsum of abdomen with a narrow median longitudinal pale stripe on all the segments, numerous short stout setae particularly on posterior margins of segments; first nine segments over twice as wide as long; tenth segment longest, not twice as wide as long, with posterior margin broadly rounded behind; supra-anal lobe (Figures 58 and 62) prominent and protruding much above apical segment, particularly when viewed from lateral aspect. Ninth ventral abdominal segment (Figure 60) much larger than other ventral segments, swollen and rounded behind, in some specimens with lobe-like appendage visible through integument; tenth ventral segment largely restricted to small lateral triangular areas between which are two well separated anal lobes. Anal cerci long and filiform (Figure 32), basal segments dark, middle and apical segments yellow-brown or whitish, with thirty to thirty-five segments, basal segments much broader than long, remaining segments much longer than wide, apical segments at least six times as long as wide, middle and apical segments each with about twelve long fine hair-like setae, basal segments with apical ring of short stout setae.

Nymphal Female.—Similar in general to the male but averaging larger in size (11 to 13 mm. exclusive of antennae and anal cerci). Apical dorsal abdominal segment (Figure 59) rounded behind and followed by a very small lobe-like structure which does not protrude above apical segment when viewed from the side. Ninth ventral abdominal segment (Figure 61) prolonged and rounded behind, eighth ventral segment with opening of oviduct visible through body wall.

TAENIOPTERYX PARVULA BANKS

Bull. Mus. Comp. Zool., Vol. LXII, No. 1, March, 1918, p. 7. ♂

T. parvula is the rarest of the three large species of winter stoneflies occurring in Illinois. Thus far it has been found only along the Rock River in northwestern Illinois and the Wabash and Ohio Rivers in southeastern Illinois. In the Oakwood region where most of the Illinois species of winter stoneflies are abundant, it does not occur. Judging by the records in literature of the occurrence of this species (this may be partly due to the lateness in recognition of the species) it is uncommon in other parts of its range. In addition to the Illinois records given in this paper, which represent a new species record for the state, *parvula* has been captured previously in but six states, namely: Maryland, Maine, Wisconsin, Minnesota, Massachusetts, New Jersey, and the District of Columbia.

It is evident from the characters of the adults and nymphs that *parvula* is very closely related to *nivalis*, but sufficiently distinct to deserve specific recognition. Since the present information concerning the nymphs, used in formulating the key to nymphs, has been derived from a study of cast nymphal skins, from one of which the adult was reared, a detailed description of this stage is not given. The fact that the nymph lacks a mid-dorsal white stripe extending from the head to the tip of the abdomen is evident from its lack in the cast nymphal skins. Also, the presence of the coxal tracheal appendages is evident by the presence of membranous scars on the coxae of the adults and the evidence of them given by the cast skins.

The adults have been collected in Illinois at Dixon, Elizabethtown, Grayville, Oregon, Rockford and Sterling; a nymph at Elizabethtown, and cast skins at Elizabethtown and Oregon.

STROPHOPTERYX new genus

Genotype *Strophopteryx* (*Semblis*) *fasciata* (Burmeister) by original designation and monobasic.

Remarks concerning this new genus and description of it have already been given on page 374.

STROPHOPTERYX FASCIATA (BURMEISTER)
Handbuch der Entomologie, Bd. 2, 1839, p. 875.

Although not previously recorded from Illinois and not as abundant as *T. nivalis*, this species of winter stonefly is common in this state, particularly in the central and northern portions. According to authentic distributional records *in litt.*, *fasciata* has about the same general distribution in North America as *T. nivalis*. Since it is the only species known to belong to this genus, the formation of a key for the identification of the species is not necessary, the generic key sufficing for this purpose. It should be mentioned, however, that the conspicuous triangular projections on the ninth abdominal sternites of the nymphs and the adult female, and the right-angled subgenital plate of the male, make this the most easily named species of stonefly in Illinois.

The males and females have been well characterized by Needham and Claassen (1925), but since the nymphs have not heretofore been recognized or characterized, descriptions of the full-grown or nearly full-grown nymphs of both the male and female are presented.

Adults of this species have been collected at the following localities in Illinois: Algonquin, Barstow, Carmi, Castle Rock, Chrisman, Como, Danville, Denrock, Dixon, Elizabethtown, Erie, Grand Detour, Grayville, Havana, Herod, Homer, Kankakee, Lexington, Mackinaw, Maquon, Moline, Muncie, Oakwood, Ocoya, Oregon, Paris, Pontiac, Rockford, Rock Island, Seymour, Sterling, Towanda, Union Hill, and Urbana.

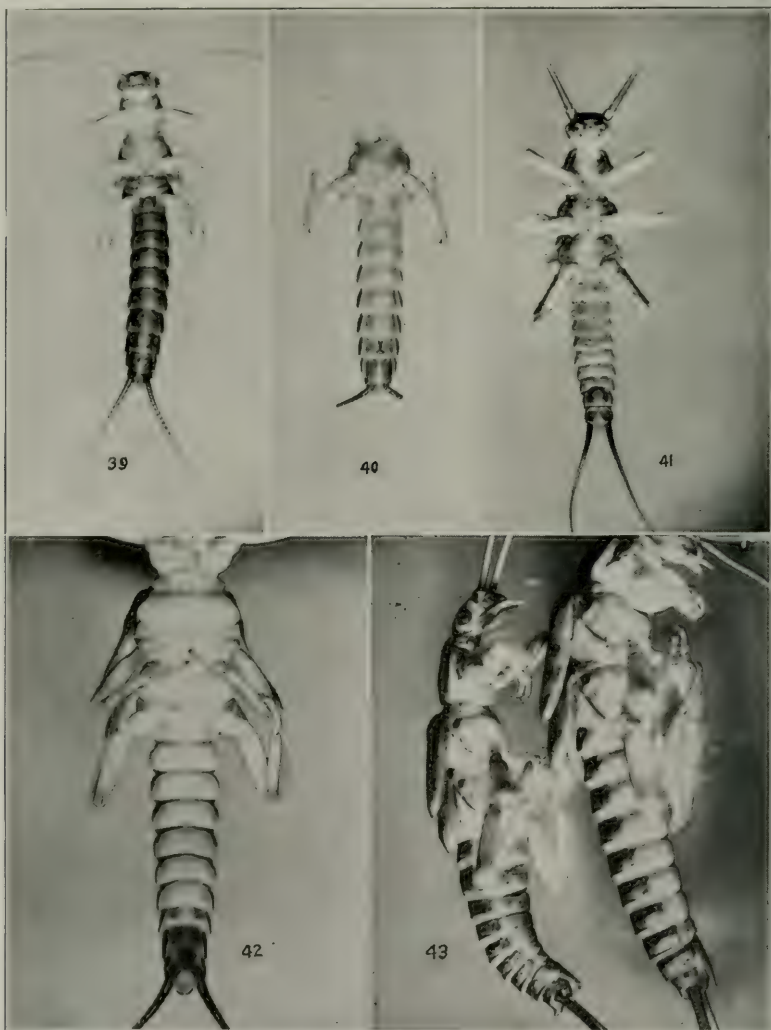
The nymphs have thus far been collected at the following localities: Dixon, Grayville, Grand Detour, Homer, Lexington, Mackinaw, Oakwood, Oregon, Pontiac, Rockford, Rock Island, Sterling, Towanda, and White Heath.

Nymphal Male.—General color of ventral surface, antennae and cerci yellow-brown; first two basal antennal segments and dorsal surface brown, particularly abdominal tergites; legs mostly yellow-brown, a narrow fuscous band near apex of each femur and base of tibia. General body form elongate and somewhat robust, wing pads protruding at an angle from sides of body, generally not over 11 mm. in length exclusive of antennae and anal cerci. Head at compound eyes about as wide as prothorax, never wider, rounded behind; epicranial stem about as long as epicranial arm; developing ocelli arranged in a triangle, posterior ocelli situated on epicranial arms over twice as far apart as distance from one to compound eye, anterior ocellus situated forward on the front about the length of basal antennal segment; labrum somewhat perpendicular to plane of front. Antennae long and filiform, with about sixty segments; first segment large, about twice as wide as second segment and about as long as three following segments, second segment wider and longer than third segment, basal segments much broader than long, succeeding segments gradually more elongate and with apical segments about three times as long as wide, setae at apex of antennal segments very minute.

Labium (Figure 14) with glossa divided into two parts by an incision which extends longitudinally as a suture about one-half the length of the ligula; glossae much smaller than paraglossae, with numerous small setae at apex; paraglossae not extending beyond glossae, nearly twice as wide as glossae, broadly curved on outer margins, with some long setae near apex; labial palpi three segmented, basal segment much the shortest, second and third about subequal in length, the latter rounded at apex. Hypopharynx lobe-like, about as large as ligula, rounded at apex and extending little if any beyond glossae. Maxillae (Figure 18) well developed; lacinia with a few teeth at apex, one of which is particularly large and blunt; galea extending slightly beyond lacinia, curved and tapering at apex, with a conspicuous sharply defined dense patch of short setae at apex; palpifer not prominent; maxillary palpi five-segmented and extending a little beyond galea, first and second segments subequal and shortest, third segment longest, fourth much shorter than fifth, the fifth slightly shorter than third and rounded at apex. Mandibles (Figure 22) heavily chitinated, with several large sharp teeth directed inwardly on apical half and with a well developed mola on basal half.

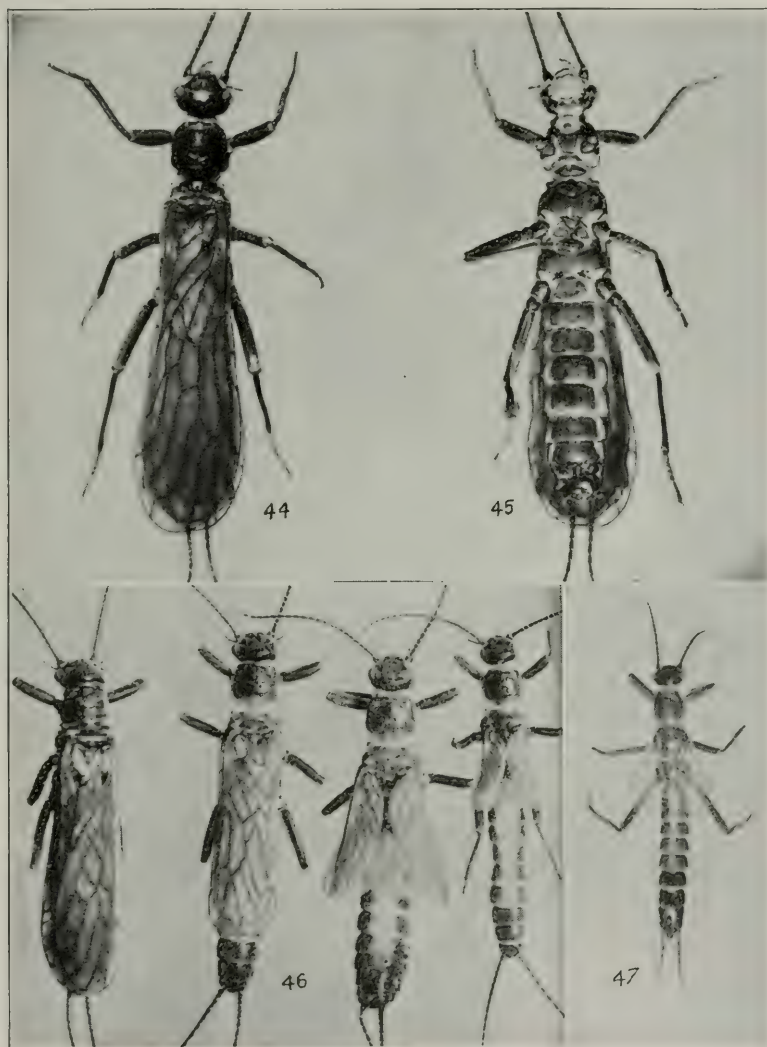
Pronotum with darkly chitinated area, much broader than long, with front and hind angles rounded, contrasting maculations on disk with rather constant arrangement. Meso- and metathorax with large wing-pads; fore pair about three times as long as wide, over-lapping base of hind wing-pads and extending at a slight angle away from body; hind wing-pads with anal lobe extending about two-thirds the length of wing, about twice as long as broad, extending at about a forty-five degree angle from sides of body. Legs (Figure 26) long, hind legs longest and extending about to apex of abdomen, fore legs shortest, tibiae slightly longer than femora but not as broad; with numerous short, stout setae on all segments and a prominent row of long slender setae on dorsal surface of tibiae and femora; tarsi three-segmented, first segment slightly shorter than the second, the second about one-half as long as the third, the latter longer than the first and second combined and with two large simple claws at apex; tibiae with two short spines at apex; coxae without tracheal appendages.

Dorsum of abdomen with darkly chitinized transverse area on each segment strongly contrasting with lighter colored intersegmental area, setae minute but particularly prominent on posterior margin of darkly chitinized



Figs. 39-43. Ventral and lateral views of nymphs: 39, female of *Allo-capnia recta* (Claassen); 40, female of *Allo-capnia granulata* (Claassen), showing indication of structure which is characteristic of eighth abdominal segment of adult; 41, male of *Taeniopteryx nivalis* (Fitch), showing coxal tracheal appendages; 42, female of *Strophopteryx fasciata* (Burmeister), showing subgenital process and lack of coxal tracheal appendages; 43, male (left) and female (right) of *Strophopteryx fasciata* (Burmeister), showing differences in size and in apical abdominal segments.

area; first eight segments at least twice as broad as long and with lateral margins rounded, ninth segment longer than eighth, tenth segment with posterior margin somewhat V-shaped; supra-anal lobe (Figure 43) prominent and pro-



Figs. 44-47. Adults of *Allocapnia*: 44 and 45, dorsal and ventral views of female of *A. granulata* (Claassen), showing long wings and venation, chitinized areas and V-shaped posterior margin of mesosternum; 46, dorsal view of four females of *A. vivipara* (Claassen), showing variation in length of wings and the dark chitinization of apical segments; 47, dorsal view of male of *A. forbesi* Frison, showing short wings, longitudinal light stripe on abdomen, and dark chitinization of three apical segments.

truding much above apical segment, particularly when viewed from lateral aspect. Ninth ventral abdominal segment without lobe-like appendage, strongly prolonged into a subgenital plate which extends backward to apex of abdomen partially covering tenth ventral segment and ventral anal lobes, apex of subgenital plate blunt and as wide as base of anal cercus; tenth ventral segment except lateral margins covered by ninth, anal lobes well separated and pointed at apex. Anal cerci long and filiform (Figure 31), basal segments darker than apical ones, with about fifty segments, basal segments much broader than long, middle and apical segments three or four times as long as wide; setae very minute and confined to ring about apex of segments.

Nymphal Female.—Similar in general to the male but averaging larger in size. Apical dorsal segment (Figure 43) rounded behind and followed by a small lobe-like structure which does not protrude above apical segment when viewed from the side. Ninth ventral abdominal segment (Figure 42) strongly prolonged into a subgenital plate which extends backward to apex of abdomen covering middle part of tenth ventral segment, apex of subgenital plate blunt but not as wide as base of anal cercus; anal lobes well separated.

ALLOCAPNIA CLAASSEN

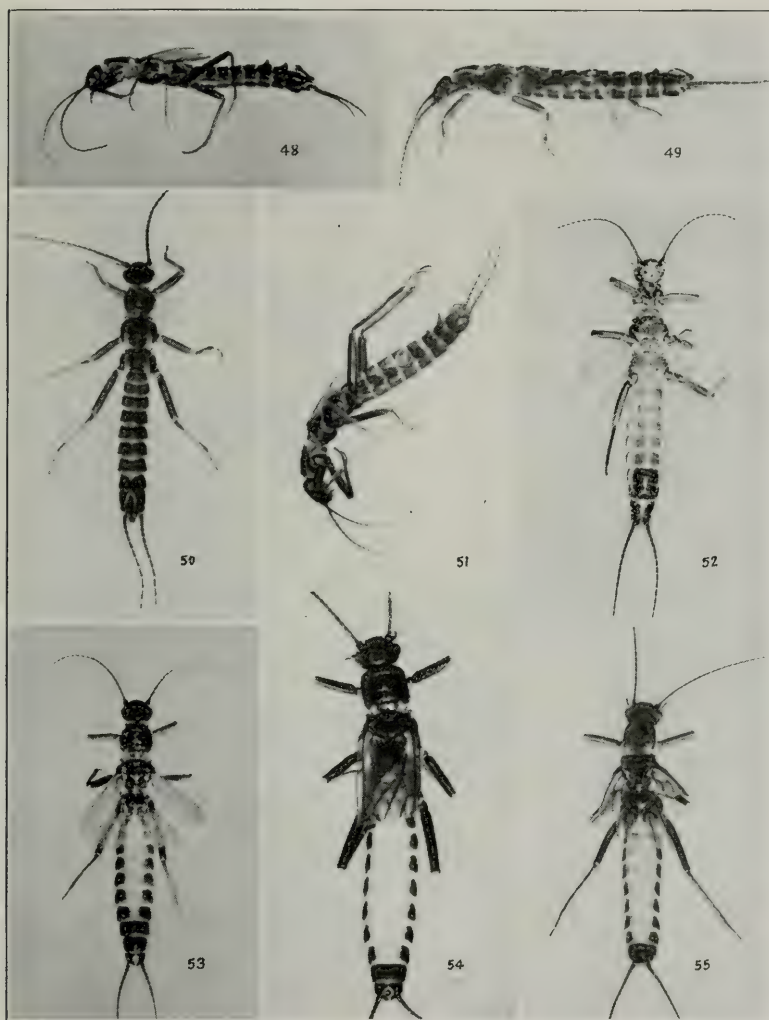
Capnella Claassen, Can. Ent., Vol. LVI, No. 2, Feb. 1924, p. 43. (preoccupied)
Allocapnia Claassen, Trans. Ent. Soc. Amer., Vol. XXI, No. 4, Dec., 1928, p. 667.
(new name)

Genotype *Capnella granulata* Claassen by original designation.

According to our present knowledge this genus is endemic to North America east of the 95th Meridian and only one species has been thus far collected west of the Mississippi River, the exception being *A. vivipara* from Missouri. Since previous to the present study but two species of *Allocapnia* have been recorded from Illinois, when we now know there are at least six, it is evident that our knowledge of the range of these interesting little stoneflies is meagre indeed.*

The males of *Allocapnia* are easy to identify because of the presence of varied and peculiar raised lobes or knobs on the dorsal abdominal segments. Needham and Claassen (1925) keyed the males of species known at the time of their monograph. The females, however, present a more difficult problem, and no key has ever been formulated for their separation. Likewise the nymphs of this genus have not been previously described or figured. This genus has its closest ally in the genus *Capnia*, which is holarctic in distribution. The nymph of a European species, *C. nigra* Pictet, has been described and figured by various investigators (Klapalek, 1909; Rousseau, 1921; and Schoenemund, 1928) and it is evident that the close relationship of the two indicated by a study of adults is substantiated by the structural details of the nymphs. The difficulty associated with the determination of the nymphs, and my reasons for leaving out a key to all of them, have already been given in detail at the beginning of my discussion of taxonomic and nomenclatorial considerations.

* See footnote on page 405.



Figs. 48-55. Adults of *Allocapnia*: 48, lateral view of male of *A. forbesi* Frison, showing short wings and knob-like protuberances on seventh and eighth abdominal segments; 49, lateral view of male of *A. vivipara* (Claassen), showing absence of wings and presence of knob-like protuberance on eighth segment only; 50, dorsal view of male of *A. vivipara* (Claassen), showing lack of wings; 51, lateral view of male of *A. granulata* (Claassen), showing short wings and knob-like protuberance on eighth segment only; 52, ventral view of female of *A. vivipara* (Claassen), showing lack of pale strip between seventh and eighth segments; 53, dorsal view of female of *A. vivipara* (Claassen), showing abbreviated wings, pale stripe on first seven segments, and dark chitinization of last three segments; 54 and 55, dorsal views of females of *A. granulata* (Claassen) and *A. recta* (Claassen), respectively, with wings clipped to show longitudinal pale stripe on segments one to eight and dark chitinization of last two segments.

ADULTS

1. Eighth dorsal abdominal segment with a raised knob-like structure (Figures 47 and 67); wings either absent, abbreviated or extending nearly to apex of abdomen (males)2
- Eighth dorsal abdominal segment without a raised knob-like structure (Figures 46 and 53); wings never absent, either abbreviated or extending to or beyond apex of abdomen (females).....7
2. Wingless (Figure 50)vivipara (Claassen)
- Wings abbreviated or long (Figures 53 and 44)3
3. Seventh dorsal abdominal segment with raised knob-like structure about as large as that on the eighth segment (Figures 48 and 66)...forbesi Frison
- Seventh dorsal abdominal segment without a raised knob-like structure as large as that on the eighth segment (Figures 49 and 51).....4
4. Wings rarely extending backwards beyond fifth dorsal abdominal segment; mid-dorsal area of abdominal segments darkly chitinated and mid-dorsal longitudinal light stripe therefore absent; species not found in Illinois in winter prior to January5
- Wings usually extending backwards beyond fifth dorsal abdominal segment, mid-dorsal area of abdominal segments pale, contrasting with lateral margins, a mid-dorsal longitudinal light stripe therefore present; species found in Illinois in fall or winter before, rarely after, January...6
5. Knob on dorsum of eighth abdominal segment deeply divided along mid-dorsal line into two more or less conical tubercles, situated before posterior margin of ninth dorsal segment; upper tip of supra-anal process (prong-like process recurved upward and forward over apical segments) with bulbous enlargement; apical segments of abdomen with hairs not much longer than those on middle segments.....pygmaea (Burmeister)
- Knob on dorsum of eighth abdominal segment not so deeply divided along mid-dorsal line that two distinct and disconnected tubercles result, situated at apex of upward and backward directed hind margin of ninth dorsal segment (Figure 51); upper tip of supra-anal process scarcely enlarged; apical segments of abdomen with hairs much longer than those on middle segmentsgranulata (Claassen)
6. Knob arising at anterior margin of eighth abdominal tergite and extending backward and upward at a forty-five degree angle (Figure 67); as high as length of seventh segment, apex of knob forming two small tubercles separated by a small cleft; supra-anal process large, nearly two times as long when extended as eighth abdominal segment.....
- Knob arising near middle of eighth abdominal tergite about perpendicular to horizontal plane of segment, height much less than length of seventh segment, apex of knob not cleft on top and forming a single small more or less round plateau-like area highest at anterior margin; supra-anal process small, scarcely longer when extended than eighth abdominal segmentmystica Frison
7. Last three dorsal apical segments (8, 9, and 10) of abdomen entirely and darkly chitinated (Figure 53), a wide longitudinal pale membranous stripe extending on dorsum of abdomen from base to hind margin of seventh segment8
- Last two dorsal apical segments only (9 and 10) of abdomen entirely and darkly chitinated (Figure 54), a wide longitudinal pale membranous stripe extending on dorsum of abdomen from base to hind margin of eighth segment9

8. Posterior transverse margin of eighth ventral abdominal segment with a small rounded lobe-like projection at its middle (Figure 73); narrow transverse pale membranous strip visible between darkly chitinized areas of seventh and eighth ventral abdominal segments in extended specimens *forbesi* Frison
- Posterior transverse margin of eighth ventral abdominal segment straight, without a projection at its middle (Figure 74); darkly chitinized areas of seventh and eighth ventral abdominal segments fused near middle, without a pale membranous strip between them (Figure 52)..... *vivipara* (Claassen)
9. Darkly chitinized areas of seventh and eighth ventral abdominal segments fused near middle (Figure 75), without a pale membranous transverse strip between them *pygmaea* (Burmeister)
- A narrow, transverse, pale, membranous strip visible between darkly chitinized areas of seventh and eighth ventral abdominal segments in extended specimens 10
10. Posterior transverse margin of eighth ventral abdominal segment almost straight (Figure 70), at most with a small outward bulge at middle of margin *recta* (Claassen)
- Posterior transverse margin of eighth ventral abdominal segment with a conspicuous, but very short, sunken projection a little less than one-third as wide as darkly chitinized area of same segment..... 11
11. Antennae stout, moniliform, basal and middle segments much broader than segments of maxillary palpi; eighth sternite with postero-median process deeply inset and sharply delineated (Figure 71); wings sometimes very dark; larger species (body 7-9 mm.); not found in Illinois in winter prior to January..... *granulata* (Claassen)
- Antennae slender, filiform, basal and middle segments not much broader than segments of maxillary palpi; eighth sternite with postero-median process not so deeply inset and sharply delineated (Figure 72); wings usually hyaline with veins dark; smaller species (body 6-8 mm.); species reaching maximum abundance in Illinois in fall or winter prior to January *mystica* Frison

NYMPHS

1. Nymphs with a conspicuous dorsal lobe-like protuberance (Figure 33) at apex of abdomen (males)2
— Nymphs without a conspicuous dorsal lobe-like protuberance (Figure 34) at apex of abdomen, apical margin broadly rounded behind.....*Allocapnia* females
2. Nymphs (Figure 36) with wing pads (winged adults)3
— Nymphs (Figure 33) without conspicuous wing pads (wingless adults)*vivipara* (Claassen)
3. Fore wing pad overlapping base of hind wing pad in large nymphs.....4
— Fore wing pad not overlapping base of hind wing pad in large nymphs*pygmaea* (Burmeister)
granulata (Claassen)
probably *forbesi* Frison
4. Dorsal lobe-like protuberance at apex of abdomen nearly twice as long from base of anal cerci to apex as length of ninth dorsal abdominal segment*mystica* Frison
— Dorsal lobe-like protuberance at apex of abdomen scarcely longer from base of anal cerci to apex than length of ninth dorsal abdominal segment (Figure 36)*recta* (Claassen)

ALLOCAPNIA VIVIPARA (CLAASSEN)

Can. Ent., Vol. LVI, No. 2, Feb., 1924, p. 46, ♂ ♀.

The adult male of this species (Figure 50) has been quite fully described by Needham and Claassen (1925). It is the most easily identified member of the genus because of its lack of well developed wings. Although the female (Figure 53) has also been described by the same authors, a few additional characters have been found which should be noted. On the dorsum of the abdomen of the female (Figure 46) a longitudinal pale membranous stripe extends to the hind margin of the seventh segment, the eighth, ninth, and tenth segments being entirely and darkly chitinized. In addition the posterior margin of the eighth ventral abdominal segment (Figure 74) is straight, without a projection at its middle, and the seventh and eighth ventral abdominal segments are fused near the middle and without a pale membranous transverse strip between them (Figures 52 and 74).

In the original description, the females are described as having very short wings, and this is true for certain specimens, but in others the wings are long or of intermediate lengths between the two extremes (Figure 46). The distribution of the females with various wing lengths is most interesting. In southern Illinois the long-winged or macropterous females are the dominant form, but a few specimens have wings of intermediate length. In central Illinois all forms are found, but specimens with wings of intermediate length are most commonly represented in our collections. In northern Illinois all our records are for the short-winged or brachypterous forms with the exception of one female with wings of intermediate length from Ft. Sheridan. Although this distribution suggests that the brachypterous females are the product of more northern latitudes, other factors such as type of stream and associated factors may be the cause. For instance, in the small stream at Oakwood (Stations II, III, IV) only the brachypterous females have been found, whereas about forty miles west in another small stream flowing into the Sangamon River near Mahomet, none of the females collected have been brachypterous, a few have been macropterous, and the majority of them have had wings of intermediate length.

Although the male of this species may be spoken of as wingless, most specimens show stubs of rudimentary wings, and in a few specimens that I have examined these wing rudiments have been very prominent. This species varies, also, in size; those in the northern and central portions of Illinois average much larger than those found near small streams in southern Illinois.

This species has previously been recorded from Illinois (the type locality, Lake Forest), New York, Missouri and Ohio. More than one thousand specimens of this species have been examined, and our collection contains specimens of the adults from the following localities in Illinois: Barstow, Bloomfield, Bloomington, Carbondale, Choat, Chrisman, Danville, Eichorn, Elizabethtown, Farmer City, Ft. Sheridan, Georgetown, Glenview, Golconda, Gossett, Grayville, Gays, Hillsboro, Harrisburg, Litchfield, Shelbyville, Stonefort, Herod, Humboldt, Lexington, Louisville, Mahomet, Mascoutah, Mermet, Muncie, Oakwood, Ocoya, Oswego, Pana, Paris, Pontiac, Rock Island, Texas City, Towanda, Urbana, Vienna, Walnut Prairie, West York, and White Heath.

The males of medium-sized to full-grown nymphs of this species are readily identified because of the absence of conspicuous wing-pads. The large full-grown females may sometimes be recognized by their abbreviated wing-pads, but where the long-winged females are found such a character is not reliable. The presence of male nymphs of this species is a sure indication that at least some of the female nymphs associated with the males are this species. In many cases, *A. vivipara* is the only species occurring in a certain stream and hence recognition of the male makes the diagnosis of the females positive to species. In other streams containing two or more species of *Allocapnia*, a knowledge of the seasonal succession of the species involved will aid in the recognition of the full-grown nymphs. As there is no fool-proof way of determining the female nymphs, one interested in securing them must intimately study the streams in his locality both from the standpoint of the adults as well as from the nymphs. Esoteric information obtained in this manner will certainly lead to their capture where this species occurs.

The following descriptions of male and female nymphs are based upon full-grown specimens from a small stream flowing into the Sangamon River near Mahomet, Illinois,—a stream in which only this species of *Allocapnia* is present. Numerous adults of this species have been taken at this same place and some reared from full-grown nymphs. Other nymphs are in the Survey Collection from the following localities: Barstow, Carbondale, Danville, Ft. Sheridan, Mahomet, Marseilles, Muncie, Oakwood, Pana, Shelbyville and Starved Rock.

Nymphal Male (Figure 33).—General color brown; antennae, labrum, mouth parts, legs, apex of abdomen, anal cerci and intersegmental areas whitish or yellowish brown and developing compound eyes dark. General body form elongate; rarely over 8 mm. in length. Head with scattered short setae, only slightly wider than the prothorax, widest at developing compound eyes, rounded behind; epicranial stem about one-half as long as epicranial arm; developing ocelli with posterior pair situated about in middle of epicranial arms, anterior one placed well forward on the front about as far anterior to posterior ocelli as distance between them; labrum somewhat perpendicular to plane of front. Antennae long and slender, with about forty-five segments; first segment very large in proportion to the remainder, basal segments wider than long, succeeding segments gradually becoming more elongate and with apical segments several times as long as wide, a few setae on segments.

Labium (Figure 15) with glossa divided into two parts by an incision which extends longitudinally as a suture nearly to base of ligula; paraglossae and glossae of about equal width and length; palpiger not appearing as basal segment of palpus; labial palpus three segmented, basal segment shortest, second segment broadest and longest of segments, third segment slightly shorter than second and broadly rounded at apex. Hypopharynx about as large as ligula, lobe-like, rounded at apex and extending but little if any beyond glossae. Maxillae (Figure 19) well developed; lacinia with several sharp teeth curved inwards at apex, beneath which on inner side is a row of long stiff setae; galea extending about as far as lacinia, curved and tapering to a point at apex; palpifer indistinct; maxillary palpi five segmented and at least twice

as long as labial palpi, first and second segments shortest, third and fifth segments about subequal in length, fourth much longer than second but shorter than third; fifth rounded at apex. Mandibles (Figure 23) heavily chitinized, with several teeth directed inwardly near apex, beneath which on inner margin is a well developed mola with smooth surface.

Pronotum with darkly chitinized area broader than long, with front angles and hind angles slightly rounded. Meso- and metanotum with conspicuous wing-pads absent, merely small rudiments present. Legs short, hind legs not extending to apex of abdomen, prothoracic legs shortest and metathoracic legs longest, femur and tibia about subequal in length, femur much broader than tibia; tarsi three segmented, second segment very small and easily confused with the first, third segment at least twice as long as first and second combined and with two simple claws at apex; tibia at apex on lower side with two very small spines which are about one-half as long as first tarsal segment; with numerous stout setae and long hair-like ones particularly on femora.

Abdomen with lateral margins of segments somewhat rounded, segments widest near posterior margin and narrower towards base, much broader than long; tenth dorsal segment with a conspicuous lobe-like protuberance at apex, longer than ninth dorsal segment; ninth ventral segment slightly prolonged behind, tenth ventral segment forming lateral triangular areas between which is an anal area extending backward between anal cerci for a short distance. Anal cerci present, long, filiform, with about twenty-eight segments, basal segments wider than long, middle and particularly apical segments much longer than wide, a few setae on each segment near apex.

Nymphal Female (Figure 34).—Similar in most details to the nymphal male, except somewhat larger. Differs as follows: wing pads well developed, of varying length, hind wing pads never extending beyond second segment of abdomen; abdomen more tapering towards apex, without a conspicuous dorsal lobe-like protuberance at apex, broadly rounded behind, ventral anal area between anal cerci bifid at apex. Posterior transverse margin of eighth ventral abdominal segment straight, never with indication of median projection (Figure 74). In some specimens the lack of a pale membranous strip between the seventh and eighth ventral abdominal segments near middle may be seen through the integument.

ALLOCAPNIA GRANULATA (CLAASSEN)

Can. Ent., Vol. LVI, No. 2, Feb., 1924, p. 44, ♂ ♀.

This species has been quite fully described in the male sex by Needham and Claassen (1925), but some additional and important characteristics of the female (Figures 44, 45, 54) should be brought to general notice. The customary longitudinal pale membranous band of the adult females of this genus extends from the base to the hind margin of the eighth segment; the ninth and tenth apical dorsal abdominal segments only being entirely and darkly chitinized. Furthermore, the posterior margin of the eighth ventral abdominal segment (Figure 71) has a conspicuous, but very short, sunken lobe-like projection a little less than one-third as wide as the darkly chitinized area of the same segment and the seventh

ventral abdominal segment is distinctly separated from the eighth by a transverse pale membranous band.

This species has been once before recorded from Illinois (Coles Co.) by Needham and Claassen (1925), as well as from New York, Maryland, and the District of Columbia. Over nine hundred specimens have been studied and we have the following locality records for the adults of this species: Chrisman, Danville, Elizabethtown, Georgetown, Grand Detour (Castle Rock), Mahomet, Muncie, Oakwood, Oregon, Oswego, Paris, Pontiac, Rock Island, Towanda, Union Hill, Urbana, White Heath; showing that it is distributed here and there throughout the state, but particularly in the central and northern portions. Nymphs known to be this species are in our collection from the region of Oakwood.

Although most of the female nymphs of this species cannot be separated in a key from nymphs of other species of this genus, and the males are readily confused with two other species, it is possible to name many of those collected because of esoteric information. There are several facts in the biology of this species which will aid the close student of the group in determining nymphs of this species. As stated elsewhere, *granulata* in Illinois is confined to large streams and rivers which do not reach a small pool stage in summer, whereas the reverse is true of the species *mystica*, *recta*, *forbesi*, and *pygmaea*.

Fortunately, too, the only species likely to be found associated with *granulata* is *vivipara*, a species easily recognized in the male sex. A knowledge of the distribution of the species in this state is also useful, since *granulata* is uncommon in southern Illinois. Furthermore, the seasonal adjustment of this species is such that the full-grown nymphs are most apt to be found when the nymphs of *recta*, *mystica*, and *forbesi* have disappeared. To avoid repetition, a detailed description of the nymphs is omitted, and only points of difference noted between nymphs known to be this species and those of *vivipara* are given.

Nymphal Male.—Similar in general form, color and structure to *A. vivipara* as described in this paper. Differs as follows: conspicuous wing pads present, the fore wing pads not overlapping the base of the hind wing pads.

Nymphal Female (Figure 35).—Differs from male in that conspicuous dorsal lobe-like protuberance at apex of abdomen is lacking and the apical margin is broadly rounded. In some specimens (Figure 40) the eighth ventral abdominal segment clearly shows in outline the sunken projection on posterior margin so characteristic of the adult female.

ALLOCAPNIA RECTA (CLAASSEN)

Can. Ent., Vol. LVI, No. 2, Feb., 1924, p. 44, ♂ ♀.

In Illinois, this species shares with *forbesi* the distinction of being our rarest members of the genus, having been found only in three small brooks in the Oakwood region (Butler's Branch, a small tributary of the Middle Fork, and at Stations II to IV). It has been recorded previously only from New York and Massachusetts.

Specimens from Illinois agree very well with the description of the male and female as given by Needham and Claassen (1925), but a few additional characters of the female should be described. The wide, longitudinal, pale, membranous stripe on the dorsum of the abdomen in the female extends to the hind margin of the eighth segment, the last two apical abdominal segments only being entirely and darkly chitinized (Figure 55). In addition, there is visible in extended specimens a narrow, pale, transverse, membranous strip between the darkly chitinized areas of the seventh and eighth ventral abdominal segments. Although the posterior transverse margin of the eighth ventral abdominal segment (Figure 70) is essentially straight, there is a slight tendency in some specimens towards the development of a small outward bulge at the middle of the margin.

Adults and nymphs from Illinois are represented in our collection by about nine hundred specimens from the Oakwood region (Stations II to IV).

The male nymph is distinguishable from other *Allocapnia* males found in this state, but the female presents no reliable characters for its ready identification. The fact that so far as known the nymphs of this species are found only in very small brooks, which reach a small pool stage in late summer or early fall, is helpful in naming the females. Furthermore, the early development of the full-grown nymphs, and the apparent absence of the species in small brooks in southern Illinois where it might be confused with *mystica*, *pygmaea*, or *forbesi*, are additional helpful hints. Characters of the full-grown nymphs are as follows:

Nymphal Male (Figure 36).—Similar in general form, color and structure to *A. vivipara*, but smaller, rarely over 6 mm. in length. Differs as follows: conspicuous wing pads present, the fore wing pad overlapping the base of the hind wing pad; dorsal lobe-like protuberance at apex of abdomen scarcely longer from base of anal cerci to apex than length of ninth abdominal segment.

Nymphal Female (Figure 37).—Differs from male in being slightly larger, in lacking dorsal lobe-like protuberance at apex of abdomen, and in having apical margin rounded. Posterior transverse margin of eighth ventral abdominal segment almost straight (Figure 39), never with an indication of a pronounced projection in middle as in *granulata*.

ALLOCAPNIA PYGMAEA (BURMEISTER)

Handbuch der Entomologie, Bd. 2, 1839, p. 874, ♂.

This species is the best known member of the genus; at least, it is recorded from more localities. Previously, it has been found in New York, Maine, New Hampshire, Massachusetts, Maryland, Virginia, and the District of Columbia. In Illinois it is apparently confined to the extreme southern part of the state, since no specimens have been taken north of Herod.

The best description of the adults is given by Needham and Claassen (1925), who mention the "broad light median longitudinal band extending to hind margin of segment eight" in the female. The darkly chitinated areas of the seventh and eighth ventral abdominal segments (Figure 75) are fused near the middle, there being no pale transverse membranous strip between them.

Over three hundred and fifty adults of this species from Illinois have been examined and were collected at the following localities: Bloomfield, Eichorn, Golconda, Herod and Vienna.

The male nymphs of this species, as indicated in key to nymphs, can be separated on the basis of reliable structural characters from other known *Allocapnia* nymphs, except *granulata*. Presence of males, however, and associated data show that we have the nymphal females as well as males from the Big Grande Pierre River near Golconda, Illinois. The fact that *pygmaea* has not been found in Illinois north of Harrisburg removes it from consideration when naming nymphs from streams in northern and central Illinois. Since the species is one which belongs to the late winter fauna, the full-grown nymphs are not likely to be found in streams in late fall when *mystica* holds sway.

Nymphal Male.—Except for being slightly smaller, similar in general form, color and structure to *A. vivipara*. Wing pads conspicuous, fore wing pad not overlapping base of hind wing pad.

Nymphal Female.—Differs from male in being somewhat larger and with apex of abdomen rounded instead of having a lobe-like protuberance. In some specimens the lack of a definite pale transverse membranous strip between seventh and eighth ventral abdominal segments is evident.

ALLOCAPNIA FORBESI new species

This unusual species was first collected in southern Illinois in March, 1927. Because of the fact that only four male specimens were found at that time, it was surmised that the species belonged to the true fall and early winter fauna. This supposition was proved correct by the capture the last of November, 1928, of numerous males and females at another nearby locality.

The outstanding difference between this new species and the remaining members of the genus is the presence in the male of a raised knob-like structure on the seventh dorsal abdominal segment about as large as that on the eighth. *Allocapnia granulata* sometimes has the seventh dorsal abdominal segment in the male humped up a little, but never in a manner comparable to that of the eighth dorsal abdominal segment.

I take great pleasure in naming this easily recognized species of stonefly after Professor S. A. Forbes, Chief of the Natural History Survey, who has made such notable contributions to our knowledge of the fresh water faunas of the state and their interrelations.

Male (Figure 47 and 48).—Length to apex of wings, 3-4 mm.; length to apex of abdomen, 6-7 mm. General color dark brown to blackish. Head slightly wider than prothorax, ocelli arranged in the shape of an isosceles triangle, the anterior ocellus situated well forward on the front, the hind ocelli almost three times as far apart as distance from one ocellus to compound eye. Antennae with about 30 segments, basal segment twice as wide as second, following segments gradually becoming less moniliform and more filiform towards apex, length of segments greatest in middle portion. Darkly chitinized area of pronotum quadrangular, slightly widened at base, angles somewhat rounded, surface wrinkled and with a faint median depressed longitudinal strip. Legs uniformly colored a dark brown or black; second tarsal joint small, about one-fifth as long as first tarsal segment. Wings of male abbreviated, usually extending little beyond third dorsal abdominal segment; hyaline, with veins dark and contrasting. Abdomen with dorsal apical segments beyond the sixth darker and more heavily chitinized than those preceding; first four anterior dorsal abdominal segments with a narrow median pale longitudinal membranous-like stripe and with traces of it on fifth and usually sixth segment; apical abdominal segments with conspicuous long hair-like setae. Anal cerci brown with 13-15 segments, basal segments somewhat moniliform, succeeding segments more filiform.

Seventh and eighth dorsal abdominal segments, both with a raised knob-like structure or tubercle (Figures 48 and 66); the tubercle on the seventh segment located on the posterior half of the segment, rising almost perpendicularly to the horizontal plane of segment, and forming a single cone-shaped projection as high as that on eighth segment; tubercle on the eighth segment gradually rising from near middle of segment; reaching its greatest height about perpendicular to hind margin of segment, forming on top two more or less sharp points which lie in the same transverse plane. Dorsal segments nine and ten with a median membranous depression or area for reception of the recurved supra-anal process; ninth ventral segment sharply rounded behind and apical margin produced, one and one-half times as long as width at base; subanal lobes terminating in short upcurved spine-like processes. Upper part of recurved supra-anal process forming a heavily chitinized shaft, almost as long as seventh and eighth abdominal segments, enlarged and diamond shaped at apex; lower part of process forming a sheath, broadly flaring towards apex, a tooth on each side near point of attachment with segment.

Female.—Length to apex of wings, 5-6 mm; length to apex of abdomen, 7-8 mm. Differs essentially from the male as follows: Wings of intermediate length, not extending much beyond sixth dorsal abdominal segment; a wide median dorsal longitudinal pale membranous strip extending from base of abdomen to hind margin of seventh segment, last three dorsal abdominal segments entirely and darkly chitinized; apical segment rounded behind; posterior transverse margin of eighth ventral abdominal segment with a small rounded lobe-like projection at its middle (Figure 73), a narrow transverse pale membranous strip visible between darkly chitinized areas of seventh and eighth ventral abdominal segments in extended specimens.

Holotype.—Male; Tributary of North Hicks Branch, Herod, Illinois, November 20, 1928, collected by T. H. Frison. *Allotype*.—Female; Same data as for holotype. *Paratypes* all collected in Illinois by T. H. Frison and H. H. Ross as follows: one male, Clay Lick Creek, Cobden, March 7, 1928; three males, South Fork of Saline River, Stonefort, March 4, 1928; two males, North Hicks Branch, Herod, November 30, 1928; forty-three males and ten females, Tributary of North Hicks Branch, Herod, November 20, 1928.

Holotype, allotype and paratypes deposited in the collection of the Illinois State Natural History Survey.

Nymphs not definitely recognized, or if present they are indistinguishable in a series of *Allocapnia* nymphs from a tributary of North Hicks Branch, Herod, Illinois, collected November 20, 1928, by T. H. Frison and H. H. Ross. No doubt when found they will be similar to the nymphs of *A. vivipara* in general form, color, and structural details. Since many full-grown nymphal males of this genus show beneath outer integument indications of a raised heavily chitinized knob-like structure on ninth dorsal abdominal segment, it is probable some full-grown nymphal males of this species will show similar indications on eighth dorsal segment.

ALLOCAPNIA MYSTICA new species

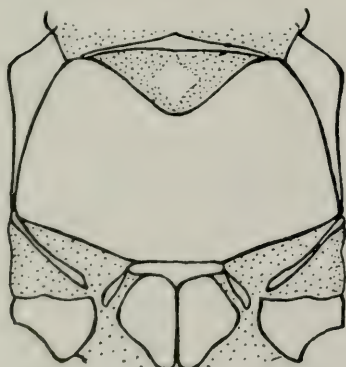
The discovery of a new species of *Allocapnia* in the Oakwood region in November, 1928, came as a complete surprise in view of previous collecting in this locality. The reason that it escaped notice in 1926 and 1927 is that it presents an excellent or extreme example of local distribution. In the fall of 1928, as in other years, it was not found at any of the places under close observation (Stations I-IV) but in another small rocky stream (Station VII) flowing into the same river about one mile downstream and previously never examined. Here it was first found in abundance on November 18, subsequently on November 21, and in diminishing numbers on December 18. In southern Illinois it was found to be very abundant in Saline, Pope, and Hardin counties in the Ozarkian Uplift south of Harrisburg, but absent in somewhat similar country in Union and Jackson counties. Ample evidence was obtained to prove that this species belongs to the late fall fauna, a few specimens hanging over until the last of February.

This species is readily separated from the other species of *Allocapnia* by the characters given in the key. The knob on the dorsum of the eighth abdominal segment of the male is quite similar to that found in *A. granulata*, but there are many important differences. The females, likewise, find their closest ally in *A. granulata*. It is interesting to note that *mystica* is a late fall and small stream species, whereas *granulata* is a winter species most abundant during late winter and showing a preference for larger streams.

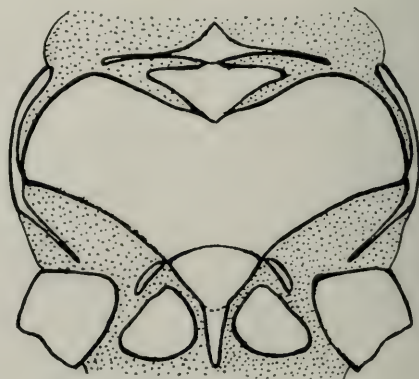
Male.—Length to apex of wings, 4-5 mm.; length to apex of abdomen, 6-8 mm. General color dark brown to blackish. Head wider than prothorax, ocelli arranged in the shape of an isosceles triangle, the anterior ocellus situated

forward on the front, the hind ocelli about three times as far apart as distance from one ocellus to compound eye. Antennae slender with about 31 segments, basal segment twice as wide as second, following segments nearly all filiform and very gradually decreasing in width from base to apex, length of segments greatest in middle portion. Darkly chitinized area of pronotum quadrangular, slightly widened at base, angles somewhat rounded, surface wrinkled and with a faint median depression longitudinal strip. Legs dark, except that middle of tibiae is paler and slightly contrasts with femora; second tarsal joint small, about one-fifth as long as first tarsal segment. Wings not abbreviated as in some species, usually extending to fifth segment or beyond; hyaline, with veins contrasting. Abdomen with dorsal apical segments beyond the seventh darker and more heavily chitinized than those preceding; first six dorsal abdominal segments with a narrow median pale longitudinal membranous-like stripe; apical segments with some long hair-like setae. Anal cerci brown with about 17 segments, basal segments slightly moniliform, but succeeding segments rapidly becoming long and slender or filiform.

Eighth dorsal abdominal segment only with a raised knob-like structure or tubercle (Figure 67); the knob arising at anterior margin of eighth abdominal tergite and extending backwards and upwards at a forty-five degree angle, as high as length of seventh tergite, apex of knob forming two small tubercles separated by a small cleft. Dorsal segments nine and ten with a median membranous depression or area for reception of the recurved supra-anal process; ninth ventral segment sharply rounded behind and apex almost pointed, about one and one-half times as long as width of base; subanal lobes terminating in short upcurved spine-like processes. Upper part of recurved supra-anal process forming a heavily chitinized shaft, about as long as seventh and eighth abdominal segments, distinctly bent downwards just before terminal enlargement, this enlargement caused by perpendicular increase in size rather than increase in width across its top; lower part of process forming a sheath, broadly flaring in middle portion and apex, a tooth on each side near point of attachment with segment.



56



57

Figs. 56, 57. Drawings of mesosterna of adults: 56, *Capnia* sp.; 57, *Allocapnia mystica* Frison.

Female.—Length to apex of wing, 6-8 mm.; length to apex of abdomen, 7-8 mm. Differs essentially from the male as follows: Wings long, extending almost to or beyond apex of abdomen; a wide median dorsal longitudinal pale membranous strip extending from base of abdomen to hind margin of eighth segment, last two dorsal segments entirely and darkly chitinized; apical segment rounded behind; posterior transverse margin of eighth ventral abdominal segment (Figure 72) with a conspicuous, but very short, sunken projection a little less than one-third as wide as darkly chitinized area of same segment, a narrow transverse pale membranous strip visible between darkly chitinized areas of seventh and eighth ventral abdominal segments in extended specimens.

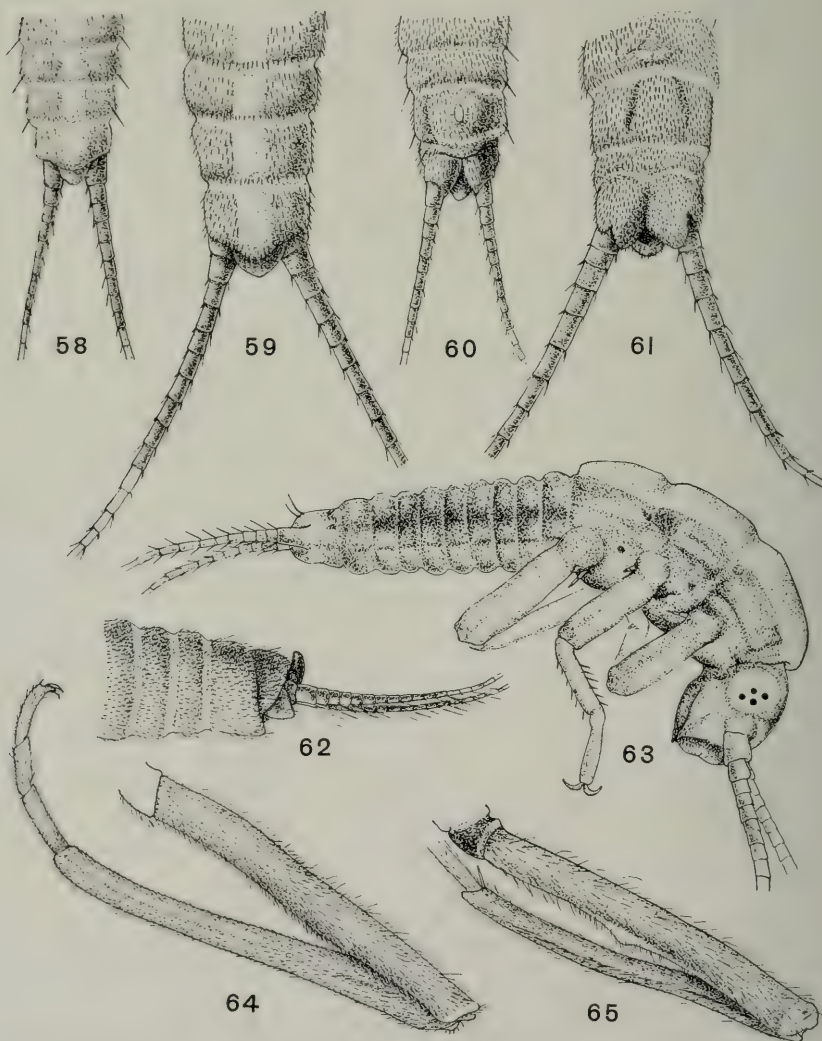
Holotype.—Male; Small tributary to Salt Fork River, Oakwood, Illinois, November 21, 1928, mating with female allotype, collected by T. H. Frison.

Allotype.—Female; same data as for holotype. *Paratypes* all collected in Illinois in 1928 by T. H. Frison and H. H. Ross as follows: eight males, Banks-ton Fork, Carrier Mills, December 1; one male and one female mating, Station VII, Oakwood, November 18; five males and five females mating, Station VII, Oakwood, November 21; two males and three females, Station VII, Oakwood, November 21; twenty-seven males and fifteen females, Station VII, Oakwood, November 18; three hundred fifty-four males and eighty-seven females, Station VII, Oakwood, November 21; seventy males and twenty-five females, Blackman Creek, Harrisburg, November 29; seventy-three males and twenty-five females, Gibbons Creek, Herod, November 29; two males and two females mating, Gibbons Creek, Herod, November 29; two hundred forty-four males and fifty-seven females, North Hicks Branch, Herod, November 30; seven females and forty-six males, South Hicks Branch, Herod, November 30; two males, Buck Creek, Eichorn, November 30; thirty males and three females, Three Mile Creek, Rosiclare, November 30; twenty-one males and two females, Bushy Creek, Herod, November 30; three males and one female, Grand Pierre River, Golconda, November 30; one male, Blackman Creek, Harrisburg, March 6; twenty-nine females, Gibbon's Creek, Herod, March 6; one male and one female, Buck Creek, Eichorn, March 6; one female, Big Grand Pierre River, Golconda, March 7; one male and one female mating, Station VII, Oakwood, December 18; fifty-four males and thirty one females, Station VII, Oakwood, December 18.

Holotype, allotype and paratypes deposited in the collection of the Illinois State Natural History Survey.

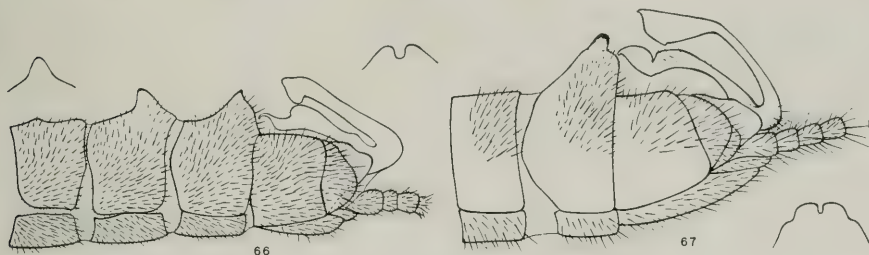
Nymphs of *Allocapnia mystica* in our collection are from Blackman Creek, Harrisburg; North Hicks Branch and Gibbons Creek, Herod; and Oakwood, Illinois (Station VII). The male is separable from other male nymphs of the genus by characters given in the key. The fact that this species is found in streams which reach a small pool stage in late summer or early fall and that it is a member of the late fall fauna are both aids in the recognition of the nymphs of this species. I have never found this species in association with *recta*; but if this does happen, as seems probable, the females could not be separated except perhaps upon the basis of a difference in size—a most unsatisfactory character. The following descriptions are based upon full-grown nymphs:

Nymphal Male.—Similar in general form, color, and structure to *A. vivipara*. Wing pads conspicuous, fore wing pad overlapping base of hind wing pad. Dorsal lobe-like protuberance at apex of abdomen nearly twice as long from base of anal cerci to apex as length of ninth dorsal segment.

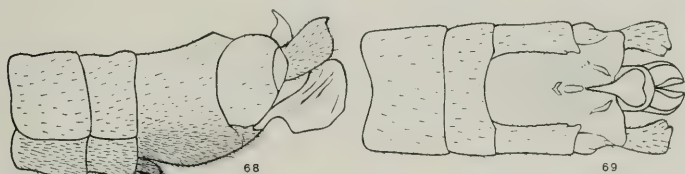


Figs. 58-65. Drawings of *Taeniopteryx nivalis* (Fitch): 58 and 59, dorsal views of apical segments of nymphal male and female, respectively; 60 and 61, ventral views of same; 62, lateral view of apical segments of nymphal male; 63, lateral view of very small nymph, showing incomplete development of compound eyes; 64, hind leg of adult typical male; 65, hind leg of adult male with indication of spur on femur.

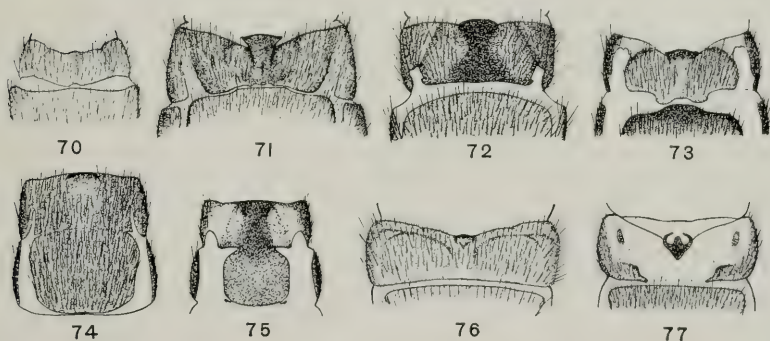
Nymphal Female.—Differs from male in being somewhat larger and with apex of abdomen rounded and not with a long protuberance. In some specimens an indication of the projection on the posterior margin of the eighth ventral abdominal segment may be seen through the integument.



Figs. 66, 67. Lateral views of apical segments of adult males: 66, *Allocapnia forbesi* Frison; 67, *A. mystica* Frison.



Figs. 68, 69. Lateral and dorsal views of apical segments of adult male of *Leuctra claasseni* Frison.



Figs. 70-77. Ventral views of seventh and eighth abdominal segments of adult females: 70, *A. recta* (Claassen); 71, *A. granulata* (Claassen); 72, *A. mystica* Frison; 73, *A. forbesi* Frison; 74, *A. vivipara* (Claassen); 75, *A. pygmaea* (Burmeister); 76, *Taeniopteryx nivalis* (Fitch) showing genital opening; 77, *T. parvula* Banks, showing genital opening.

LEUCTRA STEPHENS

Illustrations of British Entomology, Mandibulata, Vol. VI, 1835, p. 144.
Genotype *Leuctra geniculata* Stephens of Europe—subsequent designation of Enderlein, 1909.

According to Needham and Claassen (1925) no specimens of this genus have been collected in any of the central states. The finding in Illinois of two males and nine nymphs of a new species belonging to this genus is therefore of more than usual interest. Since the typic specimens come from the higher parts of the Ozarkian Uplift in Pope county, it seems probable, from the lack of comparable regions elsewhere, that the new species has a very restricted distribution in this state.

LEUCTRA CLAASSENI new species

In the key to the North American species of *Leuctra* published by Needham and Claassen (1925), this new species will best run to couplet 4, which differentiates between the species *glabra* Claassen and *infuscata* Claassen. It may be separated from *glabra* by the presence of a ventral lobe and from *infuscata* by the deeply excavated and sharply delineated area on the dorsum of the ninth abdominal segment.

It is with much pleasure that I name this species for Professor P. W. Claassen, of Cornell University, who has done so much to make known the stonefly fauna of North America.

Male.—Length to apex of wings, 8.9 mm.; expanse of wings, 14-16 mm.; length to apex of abdomen, 6.7 mm. General color yellow-brown; darker on head, and dorsum and pleurae of thorax. Head almost one and one-third times as wide as prothorax; ocelli arranged in a triangle, the anterior ocellus located about as far forward on the front as distance between the two hind ocelli, hind ocelli about three times as far apart as distance from one ocellus to compound eye, a marked pale depression between each ocellus and compound eye, hind ocelli situated about one-half length of pronotum anterior to pronotum. Antennae long and slender, with about forty segments; basal segment very large, basal segments of flagellum slightly moniliform and about as wide as long, succeeding segments more slender and filiform, those in apical half of flagellum about three times as long as wide; covered with fine setae, those at apex of segments longer and conspicuous. Pronotum about as long as wide, slightly wider at base than at anterior margin, transverse, dark, with distinct impressed anterior and posterior lines; a slightly depressed median longitudinal furrow, bisected by a slight ridge parallel with sides of furrow, about one-fifth as wide as pronotum; hind angles sharp, front angles somewhat rounded; lateral discs somewhat rugose. Legs of same general color as body; hind tibiae much longer than femora; lower part of second tarsal segment twice as long as upper part, lower part about one-fifth as long as first tarsal segment, first tarsal segment of hind leg as long as second and third combined; claws simple. Wings long, extended beyond apex of abdomen; slightly infusate, with veins brown. Abdomen cylindrical, with the first eight segments unmodified. Ninth dorsal abdominal segment considerably modified (Figures 68 and 69); dorsum

with a sharply defined longitudinal deeply impressed basin, open behind, rounded and closed near anterior margin of segment; lateral margins of depressed area forming together with posterior margin of segment a triangular projection on each side, a conspicuous tooth-like projection directed upward and inward along each lateral margin of depressed area in posterior half of its length and several smaller teeth anterior to large projection. Ninth ventral abdominal segment with a hairy lobe-like appendage at base in middle, wider than long, posterior margin of segment considerably produced and rounded behind. Tenth dorsal abdominal segment with a deeply excavate area but not sharply delineated. Anal cerci one-segmented, about twice as long as wide, with a small heavily and darkly chitinized rounded hump near apex on inner and upper side. Supra-anal lobe bulbous at base and wider than anal cerci, gradually tapering to a point from base to apex; viewed from the side it is claw-like. Subanal lobes labellae-like, large, with sac-like folds, broadly blade-like when viewed in lateral aspect; titillators absent.

Holotype.—Male; Bushy Fork, Herod, Illinois, March 6, 1928, collected by T. H. Frison and H. H. Ross. *Paratype*.—Male; Gibbons Creek, Herod, Illinois, March 6, 1928, collected by T. H. Frison and H. H. Ross. Holotype and paratype deposited in the collection of the Illinois State Natural History Survey.

As far as I am aware the nymph of only one North American species belonging to this genus has been described (Needham, 1901), and the genus has been only once placed in an American key, by Dr. Claassen in a recent pamphlet by Needham and Needham (1927).^{*} The nymphs of *Leuctra* before me, however, cannot be placed to genus in this key because the third tarsal segment is longer in all legs than the first and second segments combined. In the adult the first tarsal segment is much longer in proportion to the other tarsal segments than in the nymph—a condition that is duplicated in the case of nymphs and adults of *Allocapnia*. Unfortunately, the description of the nymph given by Needham (*Leuctra tenuis* Pictet = *tenella*) is so brief that no comparative statements can be made between it and the one described here as new. Although the adult of this species was not reared from nymphs, I am convinced that the nymphs described below in detail are the immature forms of the species described as *claasseni* because of much circumstantial evidence: the nymphs being collected in streams containing the immature forms of only two related winter stonefly genera (*Allocapnia* and *Leuctra*), the capture of adults of two genera of winter stoneflies at same time and place (*Allocapnia* and

^{*} In a paper by Uéno (1929) on the stoneflies of Japan, published while this article was in press, a single nymph was questionably assigned to the genus *Leuctra*. Since this nymph is reported to possess "neither eyes nor ocelli" I doubt that it is a true representative of this genus; for the nymph of *Leuctra* figured by Rousseau (1921) has both eyes and ocelli, and so does the nymph of *Leuctra claasseni*.

In the same paper the genus *Allocapnia* (= *Capnella*) is reported from Japan, but some features in the description of the adult indicate that it is not an *Allocapnia* in the strictest sense. The nymph was not described. The nymph figured under the name of *Takagriopteryx nigra* Okamoto is suggestive of the genus *Allocapnia* in some respects but differs in the shape of the fourth segment of the maxillary palpus. Uéno mentions that the genus *Takagriopteryx* "may be a variety of the genus *Capnella*."

Leuctra). seasonal adjustments of nymphs and adults, and morphological points of agreement between nymphs and adults (venation, mouth parts, body form, etc.).

All nymphs collected on March 6, 1928, by T. H. Frison and H. H. Ross at following localities in Illinois: Two males and one female, Blackman Creek, Harrisburg, and three males and five females, Gibbon's Creek, Herod. The following descriptions are based upon full-grown nymphs:

Nymphal Male (Figure 38).—General color yellow-brown, general body form elongate; about 8 mm. long. Head much wider than the prothorax, widest at compound eyes, rounded behind; epicranial stem about as long as one-half of width of prothorax; developing ocelli in same relative positions as in adult; labrum somewhat perpendicular to plane of front. Antennae long and slender, fifty or more segments in each antenna; first segment very large, basal segments wider than long, succeeding segments gradually becoming more elongate and with apical segments several times as long as wide, a few setae on segments.

Labium (Figure 16) with glossa divided into two parts by an incision which extends longitudinally as a suture less than one-half the length of the ligula; paraglossae about as broad as glossae combined and not extending beyond them; palpiger distinct and almost appearing as short basal segment of palpus; labial palpus three segmented, basal segment shortest, second and third segments longer than first and of about equal length, third or terminal segment less broad than second and gradually rounded and tapering at apex. Hypopharynx about as large as ligula, lobe-like, rounded at apex and not extending beyond glossae. Maxillae (Figure 20) well developed; lacinia with two slender, sharp teeth curved inwards at apex, beneath which on inner side is a row of long stiff setae; galea extending slightly beyond lacinia, curved and tapering to a point at apex; palpifer indistinct, and appearing as basal segment of palpus, maxillary palpi five-segmented and about twice as long as labial palpi, basal or first segment very short and likely to be confused with palpifer, second segment shortest and about one-half as long as fifth, third and fourth segments subequal, fifth segment a little longer than the third. Mandibles (Figure 24) heavily chitinized, with several teeth directed inwardly near apex, beneath which on inner margin is a well developed mola with some short stiff setae.

Pronotum with darkly chitinized area almost quadrate, with front angles slightly rounded and hind angles conspicuously rounded. Meso- and metathorax supporting wing pads which extend backwards nearly parallel with body. Fore wing pads long and narrow, overlapping basal third of hind wing pads; hind wing pads likewise long and narrow with anal lobe not extending much beyond middle of wing pad; venation of wing pad when distinguishable typical for genus, with numerous cross-veins between medio-cubital longitudinal veins. Legs (Figure 28) short, prothoracic legs shortest, metathoracic legs longest, femur and tibia of about equal length, femur much broader than tibia; tarsi three-segmented, second segment very small, third segment two or three times as long as the first and provided with two simple claws at apex; tibia at apex on lower side with two spines about one-third as long as the first tarsal segment; some short stout setae on ventral aspect of all segments.

Abdomen appearing cylindrical, with lateral margins of segments almost straight and not noticeably tapering towards apex; first seven dorsal segments of about equal size and slightly broader than long, eighth and ninth dorsal segments about twice as broad as long, tenth dorsal segment rounded behind and from lateral aspect somewhat lobe-like and humped up at apex; ninth ventral segment with faint indication of lobe-like appendage visible through body wall, tenth ventral segment forming triangular lateral areas between which is a large anal area somewhat pointed on posterior margin and longitudinally bisected by an incision for one-half of its length. Anal cerci present, number of segments doubtful because of broken cerci, at least nineteen in one specimen; first few basal segments about as long as wide, succeeding segments rapidly becoming much longer than wide, those towards apex much broader at apex than at base and with a row of long stiff setae around each segment near apex.

Nymphal Female.—Similar in general to the male. Abdominal segments as a whole much broader than long, apical dorsal segment broadly rounded behind and without hump-like lobe at apex when viewed from lateral aspect.

CAPNIA PICTET

Histoire Naturelle Générale et Particulière des Insectes Neuroptères.

Première Monographie : Famille des Perlides. 1841-1842. p. 320.

Genotype *Capnia nigra* Pictet of Europe—subsequent designation of Enderlein, 1909.

CAPNIA sp.

A unique female belonging to this genus was collected at Grayville, Illinois, on March 8, 1928, by T. H. Frison and H. H. Ross. Since no keys exist for the determination of the females of this genus, and males were not found to associate with the female, the Illinois representative of this genus must go unnamed for the present. Only one species—*Capnia vernalis* Newport—of the nineteen known North American members of the genus has been found east of the Rocky Mountains. This is suggestive that the Illinois specimen is this species, but it may be an undescribed one or a western form ranging eastward.

Structurally, the female agrees well with the description of the female of *Capnia vernalis* Newport as given by Needham and Claassen (1925), but since the differential or specific characters of the females of the genus have not been defined this can not be taken as conclusive proof of specific identity. It is included in this paper because its date of capture places it in our Illinois list of winter stoneflies, and in hope that mention of it will lead to interested parties discovering the male. Furthermore, the record is important because the genus *Capnia* has not heretofore been recorded from any state in the Mississippi basin.

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DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
NATURAL HISTORY SURVEY

STEPHEN A. FORBES, *Chief*

Vol. XVIII. BULLETIN Article III.

Epidemic Diseases of Fruit Trees in Illinois 1922-1928

BY

L. R. TEHON

AND

GILBERT L. STOUT



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Stephen Alfred Forbes

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This article completes the Eighteenth Volume of the *Bulletin of the Illinois State Natural History Survey* published under the direction of Stephen Alfred Forbes. Volumes I to XII, inclusive, were issued under the title of the *Bulletin of the Illinois State Laboratory of Natural History* and Volume XIII to date as the *Bulletin of the Illinois State Natural History Survey*.

Stephen Alfred Forbes was the founder of the Illinois State Laboratory of Natural History and served as its Director from 1877 to 1917. He was appointed State Entomologist in 1882 and continued in this capacity until 1917, when he became Chief of the Illinois State Natural History Survey, a division of the State Department of Registration and Education, under the Civil Administrative Code merging the State Laboratory and the Office of the State Entomologist.

In addition to the Bulletin series there have been issued under his authorship or direction three *Final Reports on the Natural History Survey of Illinois*, two volumes dealing with birds and one with fishes; the last eighteen of the twenty-nine *Reports of the State Entomologist on the Noxious and Beneficial Insects of the State of Illinois*; and numerous miscellaneous papers dealing with various phases of natural science.

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EPIDEMIC DISEASES OF FRUIT TREES IN ILLINOIS 1922-1928

L. R. TEHON AND GILBERT L. STOUT

In a wide geographical sense the diseases of fruit-trees, like those of other crops, are distributed in strict accordance with climates; and in each climatic region the particular diseases which find conditions suitable for their existence exhibit notable yearly variations both in prevalence and in severity. It is well understood that these annual fluctuations occur simultaneously with, or in some cases subsequent to, certain kinds of variations in weather; and it is generally known also that the degree of success attending the application of sprays to control disease depends to a very high degree upon the prevailing weather conditions, partly because of the great influence they have upon the growth and development of the parasitic fungi which cause diseases and partly because they determine the seasonal progress in flowering, leafing, and fruiting of the trees upon which sprays are applied.

The plant pathologist who has dealt with fruit diseases in a limited region for a number of years is able to draw upon his experience to the extent that he can, upon the arrival of very unusual weather, foresee the kind of variation in disease that will occur. He may then recommend the modifications of spray-schedules and other control operations along lines likely to reduce the menace of a disease attack which would, under the usual program of control, be certain to result in excessive injury and loss to the season's crop. But it is a fact that forecasts of this kind, which now can be made only from long personal experience, are relatively rare and can be only relatively accurate.

The natural laws which govern both the major and minor variations of disease epidemics are as yet very poorly or not at all understood. No extensive studies have been made of diseases as they occur on fruit trees, except with such specific intentions as determining the effects of sprays or ascertaining the life histories of fungi. Knowledge of plant diseases and of their causes, apart from ancient superstitions and medieval theories, has been acquired so recently that there is no body of historical information available upon which either the investigator or the fruit grower can draw for dependable guidance in forecasting the extent or destructiveness of an impending epidemic. The efficient use of fungicides is limited by the same circumstances, the application of dusts and sprays being governed mainly by the phenomena exhibited by the fruit-tree which is to be protected rather than by those exhibited by the parasites which are to be destroyed.

Nevertheless, the pressure exerted by the rapidly advancing demands of the modern agriculturalists who are engaged in the production of the fruit crops, as well as the industrialists who furnish the fungicides for the control processes, for more accurate directions and predictions, makes it necessary to have available a fund of concrete, accurate data from which to draw conclusions which, in older sciences, might be deduced from historically recorded experiences.

The practical results to be derived from the accumulation of a body of exact information on plant disease epidemics are at least two-fold. First, it is required that the manifestations of each disease shall be analyzed in such a way as to permit of measurement, with the natural consequence that there will be developed for the purpose accurate and uniform scales applicable to disease as a whole and not limited to those phases resulting in economic loss; and the present tendency to confuse crop loss with disease intensity will disappear. Second, the exactness of the accumulated data will make possible much finer comparisons than can now be made; and the effectiveness of fungicides will be increased, thereby, because of the certainty of their being applied more and more in accordance with the life-phenomena of the fungi they are intended to combat.

Since midsummer of 1921, the Natural History Survey has been engaged in studying the annual prevalence and intensity of diseases attacking the crops of Illinois. The purpose of the study has been to observe and record yearly the crop disease conditions, making the observations with such exactness and at the same time so extensively that the data and records obtained could be used subsequently to determine with accuracy the real relations existing between variations in weather and variations in plant disease epidemics. The diseases of cereals, of fruits, and of forage, vegetable, and other crops have been given time and attention each season, and two extensive reports—one on the distribution of diseases, the other on survey methods for diseases of cereal crops—have been prepared and printed.

It is our purpose, now, to present in some detail an account of the survey methods that have been developed and used in dealing with fruit-tree diseases and to state the results that have been obtained through their use. These methods are similar in certain respects to those described for cereal diseases in a former publication. Consequently this discussion has been made as brief as possible. For simpler and more detailed explanations of many of the processes used, the reader may refer to the more comprehensive discussion given in Article 1, Volume 17 of the Survey's Bulletin.

GENERAL METHODS

The aim of the fruit disease survey, as it has been conducted thus far, has been to "sample" the disease conditions prevailing in each of a considerable number of scattered localities each year and then, supposing these samples to be typical of the conditions prevailing in the regions from which they were taken, to subject them to arithmetical analysis and summarization in order to obtain numerical expressions of the general and special characteristics of each year's disease epidemics.

In obtaining the samples, various numbers of observers have traveled the country roads of the State each year since 1921 and have examined small and large plantings of fruit trees in accordance with prepared instructions. In finding and selecting orchards for examination, the Farm Advisers of many County Farm Bureaus have given cordial assistance.

During the season of 1922, the four observers then employed were required to collect a specimen of each disease found in each orchard and to make certain specific notes regarding each disease. The specimens were intended primarily to serve as a means of confirming the observer's diagnoses, but they were expected also to serve both as substantiating records and as reference material from which additional facts could be obtained by subsequent examination.

For the convenience of the observers, but especially to assure reasonable uniformity in the making of the required notes, small mimeographed blanks were provided, one of which was to be filled out as completely as possible for each disease found in each orchard examined. These blanks, with their confirmatory specimens, have been held as a permanent record of the season's work. The following example shows the form of the blank, in Roman type, and, in italics, the notes secured in an unusually well completed instance.

Collector's No. 1220

Accession No. 15,635

Crop: *Apple*. Variety: *Ben Davis*. Developmental state:

Disease: *Scab*. Cause: *Venturia inaequalis*. Type of injury: *Fruit & leaves*.

Town: *Frederich*. County: *Schuyler*. Date: *July 15, 1922*.

Date first observed: *Late May*. Source of infection:

Control measures: *Lime-sulphur*. *Calyx spray only*.

Size of field: *200 trees*. Infection: in field, *100%*; on plant: *60% of fruit.**

Reduction of photosynthetic surface: *Leaf specimen typical*.

Past prevalence: *Present every year and usually severe*.

Usual damage: *Considerable*. Estimated damage: *5% of fruit ruined*.

Association with other diseases: *Blotch, blight, frog-eye*.

Weather relations: *Dry and hot*. Additional notes: **Leaves show average of 7.5% of area occupied by scab lesions.*

Although the topics of importance in a fruit disease survey are included in this blank, the small spaces do not provide sufficient room for definite detail in the notes and a larger blank had to be devised. After several trials, the form shown on the opposite page was developed. These note sheets, 8½ x 11 inches, are printed, and are gummed into pads of a hundred. They are carried by the observer, and one sheet is required to be filled out for each disease found in each orchard. As may be seen from the example, the information they give is essentially the same as

was required by the smaller blank first used; but the larger form has the two advantages of allowing fuller notes on most points and of permitting complete statements of counts made by the observer.

1928

PLANT DISEASE RECORD BLANK

Crop *Apple*. Disease *Scab (Endostigme inaequalis)*
 County *Cumberland*. Locality *Neoga*.

Variety of crop *Stayman's Winesap*. Size of field *1,000 trees*.
 State of development *Trees 26 years old. Season's fruit 2" in diameter*.

Control measures $\left\{ \begin{array}{l} \text{Applied } X\text{-spray.} \\ \text{Not applied} \end{array} \right.$ $\left\{ \begin{array}{l} \text{Kind used Oil (dormant) and} \\ \text{lime-sulphur.} \end{array} \right.$

When used: *Dormant spray; cluster-bud spray omitted; 4 applications of lime-sulphur. Thorough applications with considerable spray burn on the leaves.*

INFECTION: Percentage of trees diseased *100*. Leaf infection *3.28% of area*.

Scale classes:
 0— 5—10—15—20—30—45—60.

Data: Fruits examined *673*
 Fruits infected *146*
 Per cent. infected *21.7*

Class frequency:
 125+ 33+ 7+ 4+ 3+ 2+ 1+ 2=177.
 Class values:
 0+165+70+60+60+60+45+120=580.

Type of injury *Abundant but light infection on fruit. Light infection on 29% of the leaves.*

Estimated damage *(Not determinable at date of this report.)*

Date first observed *May 29th*. Source of infection *Probably old leaves*.
 Past history *Orchard clean before 1927. Increased infection this year may be due in part to omission of cluster-bud spray.*

Association with other diseases *Black-rot, blotch, fire-blight, and rust also present in this orchard. See particular reports for each.*

Additional notes (weather, phenology, etc.) *Spring was cool, the month of June exceptionally wet, and July hot.*

Date of observation *August 1, 1928*. Specimen No. *S-379*; Acc. No. *21545*.
 Observer *G. L. Stout*.

The blank is designed to record information regarding one disease only. This is seen to be practically a necessity when it is considered that a very considerable number of orchards may furnish data on each of several diseases in a given season and that, for convenience in study, the numerous records pertaining to one disease must be kept together. In addition to the geographical situation of the orchard, the pertinent facts

given on each blank include a statement of the fruit variety, the number of trees in the plantation, their age, and the stage in seasonal development of the fruit or other structures at the time of examination, as well as information regarding the application of control measures, all of which may be essential in interpreting the data given in the other spaces.

The tree is taken as the unit of survey; and it is our custom, in examining large plantations, to prepare separate reports for each horticultural variety, thereby securing accurate information relating to the differences in predisposition to disease attack exhibited by the more common varieties of each kind of fruit grown in the State.

The data taken on the season's manifestation of disease is concerned particularly with two distinct phases: first, the *prevalence* of the disease, which we express as the percentage of trees suffering from attack in diseased orchards and second, the *intensity* of the attack, which we determine as (a) the percentage of fruits attacked; (b) the amount of woody growth diseased or destroyed; and (c) the destructive effect on leaves, expressed as destroyed or occupied leaf area. Some diseases do not, of course, exhibit all these phases, and from them the data which can be acquired are limited to the types of disease they produce.

The observer, in all the processes of gathering data, must consider only the disease. The commercial effects of disease, seen as reductions in the grade of fruit or in lowered yields, are secondary things, well recognized by the fruit grower but quite apt to be misleading in a study of the epidemiology of disease.

In gathering these data, the observer is required first to determine the number of trees that have become diseased in the plantation in which he is working, and this determination he expresses as a percentage on the record sheet. When the disease is a prevalent one and the variety susceptible, this percentage, or prevalence "index," may be ascertained by a brief examination; but with rarer diseases, exceptionally good control, or resistant varieties, more care is required.

To determine the prevalence of fruit infection on the diseased trees, it has been found necessary to make a definite count of the observable fruit on each tree, as the tree is examined, and to distinguish between the fruits that are infected and those that are not infected, as the count is in progress. On the sample record, it is indicated that 673 apples were seen, of which 146 were seen to be infected by, and 527 free of, scab: and from these data it is considered that infection had occurred on 21.7 per cent of the fruit.

As the observer conducts his examination, he also gathers a random sample of leaves, which, to conclude his examination, he compares with a set of standard, measured diagrams, or scales, with which he is provided, and thereby secures an estimate of the amount of disease present on the leaves. The manner in which one such a diagram is used is described in the discussion of apple scab. The only explanation that needs to be made here is that, in obtaining the data shown in the sample record, 177 leaves were scaled, 125 of them being either free of infection or only very slightly diseased, while various numbers of the remaining 52 were diseased to the extent indicated by the scale classes under which the numbers are placed. The average amount of leaf area occupied by

scab lesions in this sample was 3.28 per cent. This figure we regard as an "index" expressing the intensity of the scab attack on leaves in the orchard.

When the record blanks have been completed, the collector sends them, often with substantiating specimens, to headquarters, where, as they accumulate, they are assorted by crops and by diseases, those for each disease of each crop being assigned a special folder for each year. The substantiating specimens are subjected to careful identification, often by microscopic examination and occasionally by culturing on artificial media, and then, designated by newly assigned accession numbers, they are preserved in the Natural History Survey's mycological collection for permanent reference.

ANALYSIS OF DATA

At the close of each season's work, it is necessary to analyze and summarize the accumulated records, and in order that the results obtained from data gathered in one season may be comparable with those of other seasons, this must be done in a uniform manner. In general, the process is the same as that outlined for cereal diseases in a previous article; but there are slight differences which require some explanation.

The current season's record sheets for each disease, already assorted, are now arranged alphabetically by counties and numbered in sequence, and the data which they furnish are assembled in a series of tabulations, only one of which has been used in preparing data for this discussion. It is made up in the manner illustrated by the very much abbreviated example shown in Table I.

One line across this table carries all the data on prevalence and intensity given by one record sheet and shows, besides, a number of simple computations made from them. The number of the record sheet appears in column 1 and serves as a reference to the place in the folder from which the data are taken. Column 2 shows the name of the county in which the examined orchard was located. As the record sheets have been assorted by counties, all the records for each county represented in the season's accumulation are grouped on consecutive lines, and column 3 then shows not only the number of trees represented by the individual field-record sheets but also the total number of trees represented by the examinations conducted in each county and in the state.

Column 4 shows the percentage of diseased trees in every infected orchard examined, as given by the individual records, and also gives weighted averages of these percentages for each county and for all records taken during the season. The weighted averages are obtained with the aid of the figures which appear in column 5, which we have termed "prevalence products." They are secured by multiplying each entry in column 3 by its corresponding entry in column 4. The purpose of this is to give a proper relative weight, in terms of the particular number of trees to which each percentage applies, to each of the prevalence percentages, so that when all the data obtained in one county, or in the State, are brought to an average, the observations made in small and possibly uncared-for orchards will not unduly influence those made

in plantations of 500 to 1000 or more trees. As an example, suppose the short list of observed prevalence percentages given for Calhoun County in the sample table be added and divided by 4. The sum is 300.4 and the quotient is 75.1 per cent. But by weighting the prevalence percentages observed in each orchard in terms of the number of trees in each, the proper relative importance is given to each of the observations, and the prevalence index, equivalent to the previous quotient, is determined as 68.8 per cent. Since the difference between the apparent average of 75.1 per cent and the weighted average of 68.8 per cent amounts, in this one instance, to 6.3 per cent, it may

TABLE I

EXCERPTS FROM THE SUMMARY OF FIELD NOTES ON THE PREVALENCE AND INTENSITY OF THE SCAB DISEASE OF APPLES IN 1928

Record sheet number	County	Number of trees in orchards examined	Prevalence: Proportion of trees with infection		Intensity of disease attack			
			Observed percentage	Prevalence product	Diseased fruit		Leaf disease	
					Observed percentage	Prevalence intensity product	Observed percentage	Prevalence intensity product
1	2	3	4	5	6	7	8	9
1	Calhoun.....	75	100.0	7,500	4.0	30,000	0	0
2	Calhoun.....	1,000	100.0	100,000	25.0	2,500,000	*T	0
3	Calhoun.....	25	100.0	2,500	50.0	125,000	1.00	2,500
4	Calhoun.....	500	0.4	200	T	0	0	0
	Total.....	1,600		110,200		2,655,000		2,500
	Weighted averages.....		68.8		16.6		0.01	
23	Clark.....	180	100.0	18,000	18.0	324,000	T	0
24	Clark.....	80	100.0	8,000	2.0	16,000	0	0
25	Clark.....	200	100.0	20,000	0	0	6.71	134,200
26	Clark.....	85	100.0	8,500	0	0	3.87	32,895
	Total.....	545		54,500		340,000		167,095
	Weighted averages.....		100.0		6.24		3.07	
64	Pike.....	352	100.0	35,200	4.0	140,800	0.30	10,560
65	Pike.....	520	100.0	52,000	1.0	52,000	T	0
66	Pike.....	500	100.0	50,000	3.0	150,000	2.00	100,000
67	Pike.....	1,600	100.0	160,000	10.0	1,600,000	1.18	188,800
	Total.....	2,972		297,200		1,942,800		299,360
	Weighted averages.....		100.0		6.54		1.01	
	Total.....	5,117		461,900		4,937,800		468,955
	Weighted averages.....		90.27		9.65		0.92	

* The symbol T is used to indicate the presence of infection, when the actual amount is too small to measure. Its statistical value is considered to be 0.

readily be seen that the use of corrective weighting throughout the table assures a much more accurate final index.

The remaining columns of the table deal with the intensity of the disease, and the nature of the data used in them depends, of course, upon the types of manifestation characteristic of the disease. The disease illustrated in the sample table is apple scab, which in Illinois very rarely causes appreciable damage to either the blossoms or the woody parts of the tree; hence, the points of importance to be considered in determining the intensity of its attack are (a) the number of fruits infected and (b) the amount of leaf tissue destroyed. In the case of other diseases, such as fire-blight and blotch of apple, measure-

ment of seasonal intensity would include twig infection and perhaps blossom blight.

The observed percentages of diseased fruit recorded on the record sheets and entered in column 6 apply to diseased trees only. In order to secure an infection index for all trees, it is necessary to compute a "prevalence-intensity product" by multiplying each prevalence product in column 5 by its corresponding intensity percentage in column 6. This is entered in column 7. In effect it gives a proper relative weight to each recorded intensity observation, with the result that the intensity indexes for counties and for the entire set of data are considerably more accurate.

The observations on leaf intensity are entered in column 8. These figures, like those for fruit intensity, apply only to diseased trees, and prevalence-intensity products must be computed for them also, and in the manner just explained for the fruit intensity data.

When all the data given by the field-record sheets have been transferred to the table and the proper prevalence and prevalence-intensity products computed, indexes of prevalence and of intensity applicable to the entire set of observations can be secured by finding the totals of columns 3, 5, 7 and 9, and then dividing each of the three latter sums by the first.

The indexes which have been obtained by the completion of this table express concretely the prevalence of the disease and the intensity of each phase of its attack, as exemplified in the orchards subjected to examination in each county in which observations were made and in all the orchards in which data were taken.

If these orchards have been numerous enough and their distribution sufficiently wide and representative, the final indexes of the table will be statistical expressions of the average disease conditions prevailing in the orchards of the State for the year; but as it usually is impossible to examine so large a number of orchards carefully, additional treatment is needed in order to obtain satisfactory indexes from the data secured. The results computed from observations made in one county usually vary to a greater or less extent from those of an adjacent county; and this variation, though influenced by the number of orchards actually examined as well as by errors inevitable in random sampling, often expresses real differences in the disease epidemics, due to the predominant use of varieties differing in their predisposition to disease, to cultural practices, or to the extent to which effective control measures are employed. The disparity between indexes obtained for any two counties nevertheless applies directly to the majority of orchards of those counties; but since counties seldom have the same number of trees, the average disease condition for a two-county area is necessarily different from that shown either by the sum of the orchard examinations or by an average of the indexes of the two counties.

A proper adjustment of values may be obtained, however, by weighting the indexes for each of the counties in proportion to the number of trees in the respective counties. This process is, of course, necessary for all the counties in which data have been taken, and a separate tabulation with accompanying computations can be made.

The number of trees per county, the most important item in this step, is not directly available and so must often be estimated. The agricultural reports of the Bureau of the Census give the number of trees only for the years 1919 and 1924. For the intervening years, the number of trees per county may be estimated closely by securing the difference between the given years, dividing this amount into 5 equal parts (unless there is reason for adjusting the years otherwise), and according as the change was either an increase or a decrease, adding or subtracting one of the 5 parts for each year subsequent to 1919.

As an example, the number of apple trees in Bond County in 1919 is given in the Census Reports as 87,346. In 1924, this number had fallen to 59,483—a decrease of 27,863 trees. During this five-year period the average yearly decrease was 5572.6 trees, and the number of trees presumed to each year was: 81,773 in 1920, 76,200 in 1921, 70,628 in 1922, and 65,055 in 1923.

Subsequent to the 1925 agricultural census, data of this kind are not available and will not be again until the results of the 1930 census are made public.

The employment of data of this kind may be illustrated by using the indexes obtained in the foregoing sample table and weighting them in sample Table II, below, in terms of the total number of trees per county.

TABLE II

AN ILLUSTRATION OF THE ADJUSTMENT OF COUNTY PREVALENCE AND INTENSITY IN TERMS OF THE TOTAL NUMBER OF TREES EACH REPRESENTS

County	Trees per county	Prevalence		Intensity of disease			
		County index	Prevalence product	On fruit		On leaves	
				County index	Intensity product	County index	Intensity product
1	2	3	4	5	6	7	8
Calhoun.....	777,154	68.8	53,468,195	16.60	12,900,756	0.01	7,771
Clark.....	6,219	100.0	621,900	6.24	38,806	3.07	19,092
Pike.....	251,286	100.0	25,128,600	6.54	1,643,410	1.01	253,798
Total.....	1,034,659		79,218,695		14,582,972		280,661
Averages.....		76.56		14.09		0.27	

The makeup of this table is essentially the same as that of Table I, except that the intensity indexes given in columns 5 and 7, having already been determined in Table I as applying to average trees, are used without reference to the prevalence index given in column 3. Hence, the "intensity products" of column 6 and 8 are products obtained directly by multiplying the number of trees per county given in column 2 by the intensity indexes given in column 5 and 7, respectively.

The final averages, or averaged indexes, derived from this sample calculation differ considerably from those obtained in Table I. The prevalence index has been reduced from 90.27 in Table I to 76.56 in Table II; the index for intensity of fruit attack has been raised from 9.65 to 14.09; and the index for intensity of leaf attack has been

lowered from 0.92 to 0.27. These differences, though much greater in the two brief examples than in the actual extended tabulations, nevertheless serve to illustrate how desirable it is to take into account the entire number of trees per county, the disease condition of which is represented by the individual observations, or samples, tabulated from the field record-sheets. It is, of course, apparent that the indexes with which Table I closes apply only to the orchards which have furnished data, while in Table II the entire number of trees in the territory where sample orchards were examined is taken into account, with the result that the final indexes of Table II apply to all these trees, whether they are inside or outside of the sample orchards.

Geographically, cropping in Illinois follows rather well defined plans. This has been recognized in the preparation of agricultural statistics to the extent that nine districts have been delimited. A considerable inequality exists with respect to the number of trees in these statistical districts, but this may not be represented adequately in the field examinations. To overcome this discrepancy, as well as to counter-balance the high amount of disease usually found in small-orchard regions, where spraying is not so generally or carefully done, so that the data taken there do not outweigh data taken in regions of dense fruit-tree populations, where commercial production is the aim and sprays are applied with care and success, a third tabulation of data and computation of indexes is often necessary. For statistical purposes, the State is divided from north to south into four sections of about equal length, and through these sections run longitudinal lines separating the north section into two approximately equal portions, the next section into three portions, and each of the two southern sections into two portions. The lines of division have been made to conform to county boundaries. Observations made in any one of these districts, after having been properly weighted in Tables I and II, may be extended to apply statistically to the entire fruit tree population of the district, and the calculation of the weighted district values gives a series of indexes showing the prevalence of a disease and the intensity of its several types of infection throughout the State. This process of equalization, described fully in our account of cereal diseases, is essentially as illustrated in Table III.

As a matter of practice, we have not yet been able to make consistent use of Tables II and III for our Illinois data. The making of these analyses is, as is of course apparent, entirely dependent upon having complete agricultural statistics at hand; but these statistics, provided at present only by the Bureau of the Census, are not issued concurrently with the gathering of our data. They are made available once in five years, and it is only after they have been made available that the fruit disease data collected during the preceding five years can be considered in all ways. The result is that, since no new statistical reports of a suitable character have been at hand since 1925, the observations we have made during the last four years can be made to apply only to the particular orchards in which they were taken; and because the years of this period number more than half of the years included by our survey, all the data presented on subsequent pages have been made to conform to this limiting condition.

LIMITATIONS OF DATA

The data upon which the discussions in this paper are based have been taken during the growing seasons of the past seven years. No two of these seasons have been alike, either with respect to disease phenomena or with respect to the number, experience, and capabilities of the observers who gathered the data. It has been necessary, also, for us to conduct fruit-disease and cereal-disease surveys simultaneously; and there has been, as a consequence, a certain amount of interference by each of these surveys in accomplishing the objects of the other.

Up to the time the survey was undertaken, no similar investigation of crop diseases had ever been made. There were no methods of procedure at hand which could be adapted to our use, nor was there any adequate body of experience upon which to draw for guidance. It is true that limited surveys had been made in various places, but these were concerned with one disease of one crop, were made for an immediate purpose, and had in view the object of determining either the extent of distribution or, vaguely, the immediate threat of the disease. The experience of entomologists was pretty largely invalidated by the inherent differences in size, habits, and methods of reproduction that exist between insect pests and parasitic fungi.

We were therefore faced by the necessity of accomplishing simultaneously two tasks—developing methods and gathering data. Our first work was quite as crude as the methods first conceived; but with improvement in method the value and reliability of the data have improved also; and in this connection it has been an especially fortunate circumstance that during the first years abundant specimens were gathered and preserved as records to which we have since been able to turn for re-examination with great benefit to the quality of our early records.

The investigation of crop diseases in the open eventually resolves itself into a statistical problem, and in this respect the diseases of fruit-trees present an especially difficult task. Practically all of the cereals and most of the vegetables come from herbs that are limited to one year of life, and their diseases, at least so far as seasonal epidemics are concerned, are limited in the main to some particular plant part, such as stem, leaf, flower, or seed. Fruit-trees, on the other hand, are woody perennials, and each of their serious diseases is able to attack several parts of the tree. The destructive effect of a cereal disease usually may be measured directly in terms of the one part of the plant that is attacked; but a fruit-tree disease, which may begin the season by destroying the blossoms and continue by killing the new growth, injuring the leaves, and marring or rotting the fruit, often exhibits seasonal variations in the intensity of each of these types of attack, the sum of which gives it its destructive effect. Each effect must therefore be measured separately. For certain diseases, one or more types of attack are so rare or do so little injury that they can be ignored, while certain other types of attack—notably injury to the fruit—vary so much in severity that it is impossible, in a general survey, to do more than to note the amount of diseased fruit.

Moreover, it is permissible to take cognizance only of the disease, as it is expressed in its effect on the tree. To attempt to express the

disease attack in terms of a possible commercial loss alone is not within the province of such a survey, as the actual loss of fruit, or the reduction in commercial value as it affects the crop, may be greater in the year of a mild epidemic than in the year of a heavy epidemic, according to the time of the disease attack, the subsequent conditions of the market, or the prices offered.

There has been a very considerable yearly variation both in the manner in which we have collected data and in the amount of data secured. In the first season, that of 1922, four observers were active, and the largest quantity of data that we have been able to obtain in any one year was taken. The progress of the survey that season was materially advanced by the cooperation of the County Farm Advisers, who willingly helped in locating orchards and very often furnished transportation to the field men. In the seasons of 1923 and 1924 there were but two observers; in 1925 the number was reduced to one; and since then there have been two each season.

Coincident with the development of more painstaking and accurate methods of surveying, there has been a decrease in the number of orchards examined and in the amount of data taken in a season; but this is more than balanced by the increased dependability of the records.

FRUIT-TREE DISTRIBUTION

The number of fruit trees of various kinds grown in each of the several sections of Illinois has an important bearing upon the amount and kind of data that can be obtained from each section in the course of a survey such as ours; and the cultural and disease-prevention practices, which are naturally much more adequate where fruit production is a major interest, as well as the location of orchards with respect to the geographical range of one or more diseases, strongly influence the character of the data as well as its significance when subjected to statistical analysis.

As an aid in understanding the data presented on later pages, therefore, the reader should have in the background of his thoughts a general picture of the fruit-tree population of Illinois. The latest available figures¹ indicate a total of a little over 12,821,000 fruit trees, of which about 6,764,000 are apples, 4,139,000 are peaches, 767,000 pears, 754,000 cherries, and 395,000 plums and prunes.

The location of these trees is such as to permit a rough grouping of the counties of the State, as shown in Figure 1, into three divisions, in each of which the number of trees, and the consequent intensity of fruit production, is essentially uniform. Throughout the northern half of the State orcharding is a minor interest, and the orchards are, for the most part, small and scattered. The total number of trees in this section is about 2,799,000—approximately 22 per cent of those in the State—and the average density of the tree population is about 89 to the square mile. In the central section fruit growing is a more important interest; and though it is true that the orchards of this region are also mostly small and scattered, there is a scattering of large

¹ The 1925 agricultural census furnishes data for apples, peaches, pears, plums and prunes but the figures of the 1920 census have to be used for cherries.

orchards, and Calhoun County bears the distinction of being the most important apple-producing county in the State. The number of fruit trees in this middle section is a little over 3,764,000—about 29 per cent of those in the State—and the tree population, about 262 per square mile, is nearly three times as dense as in the northern section. In the southern section, fruit production is an important commercial occupation. Here the orchards are large and frequent, and generally they receive good care. The number of trees in this section, a little over 6,268,000, amounts to 49 per cent of all those in the State, and the tree population, which reaches the high average of 614 per square mile, is

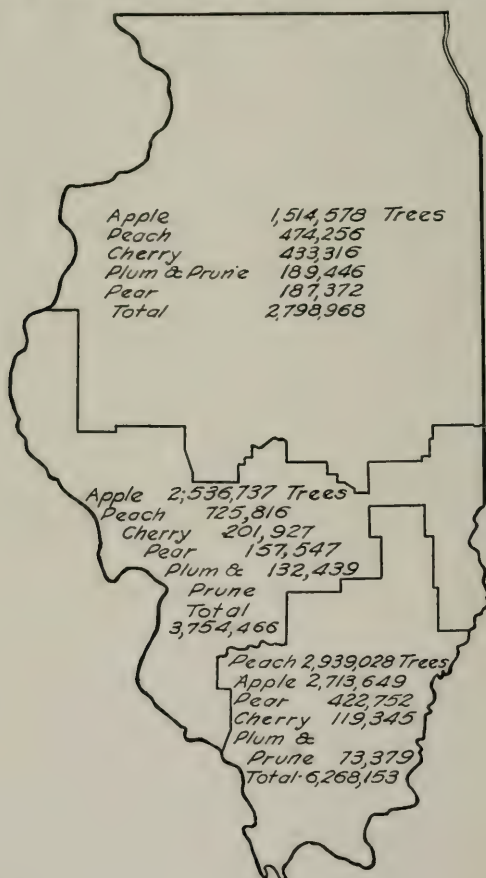


FIG. 1. THE FRUIT-GROWING REGIONS OF ILLINOIS

In the northern half of the state fruit production is not generally carried on as a commercial enterprise. The apple is the most common tree; but with the exception of a few large plantations it and the other fruit trees are grown in small farm orchards. The southern half of the state has two fruit regions which are distinguished chiefly by the density of fruit tree population, but in both regions commercial production of apples and peaches is the common practice. Further discussion is given in the text.

about seven times as dense as that of the northern section and 2.3 times as dense as that of the central section.

The order of importance in which the various kinds of fruits stand also varies from section to section, as may be seen in Figure 1. In the northern and central regions, apples rank first and peaches second, while in the southern section this order is reversed. In the north apples are generally the only trees planted for a commercial crop, while peach, cherry, plum, and pear trees, numbering in their aggregate only about four-fifths of the total of apple trees, are seldom found in extensive plantings.

In the central section, apples and peaches both furnish commercial crops, and there are occasional pear plantations. Plums and cherries, also, are of more importance than in the north, though the plantings are generally small and scattered.

In the south, there has recently been a very decided stimulation in the planting of peach trees, and they now outnumber the apple trees by more than 200,000. The most intensive pear-producing regions of the State are also in this section, notably in Marion, Union, and Pulaski counties, and plums and cherries together, which are only one-third as abundant as pears, constitute only 3 per cent of the entire number of fruit trees, although when the areas of the several sections are considered they are of nearly the same importance as in the central section and are even more important than in the north.

In addition to these general features, each section has, of course, certain particular characteristics. In the north, commercial apple and peach production has been developed especially in Peoria, Tazewell, Fulton, and Bureau counties. Similar regions of especially intense production include Adams, Pike, Calhoun, and Jersey counties in the central section and Marion, Jefferson, Johnson, Williamson, Union, Jackson, and Pulaski counties in the southern section. The other counties in each section are fairly uniform. From north to south, through the State as a whole, there is, however, a gradual but very evident increase in the number of fruit trees per county.

APPLE DISEASES

The diseases attacking apple trees in Illinois can be classified rather conveniently as being either annual or permanent in their nature. Those that are classed as annual appear on the trees season after season but leave the trees more or less free from infection during longer or shorter periods of each year, at least in the case of one or more of their modes of attack. They are, therefore, the diseases which properly may be called epidemic.

Permanent diseases, on the other hand, stay with the trees they attack and continue to enlarge their destructive effects from year to year, though they are, of course, quiescent during the winter season. Represented in Illinois by the nail-head, fire-blight, bitter-rot, blotch and black-rot cankers, they are diseases of the larger, older, woody parts of the tree; and in those parts they persist, unless adequately treated, from the time of infection to the ultimate death of the tree. It is probable that their injuriousness varies from year to year; but their

effects are very difficult to measure and the results of such measurements so uncertain that in the main they are excluded from consideration at this time.

The annual, or epidemic, diseases, though in many instances resulting from the same fungi or bacteria as cause the permanent diseases, generally attack the leaves, the twigs, the flowers, or the fruits; and though they may arise directly from infective material furnished by their permanent forms, their effects are usually limited to a single growing season. Each year brings a new attack, which varies from the attacks of every other year both in prevalence and in severity.

APPLE SCAB

Caused by *Endostigme inaequalis* (Cke.) Sydow

The scab disease of apple, the most widely distributed and most serious apple disease in North America, occurs throughout Illinois. It may attack the blossoms, the young twigs, the leaves, and the fruit, though generally only the leaves and fruit are injured to an appreciable extent. In Illinois, all four of these types of infection are known to occur; but the twig and blossom infections are generally so mild that they need not be given consideration. Leaf and fruit infection is usually severe in all parts of the State; but as a rule the injury is greatest in the north and is replaced to a certain extent in the south by blotch injury.

The effect of scab upon either the fruit or the leaves depends to a considerable extent upon the time at which infection takes place. When it occurs on young apples it often results in the production of small, misshapen, badly scarred, or cracked fruit that is of little value. Certain varieties of apples, however, have the ability to resist scab attacks, and the crops taken from these varieties, even in bad scab years, usually show only a very small percentage of scabby fruit, much of which is of a salable grade due to the healing, or "corking over," of the scab spots during the growth of the fruit.

Our comparisons of the year-to-year fluctuation in the amount of fruit infected with scab has therefore been limited to estimates of the percentage of apples bearing scab spots, and no consideration has been given to the very apparent differences in the degree of commercial damage to infected fruit resulting from the size or number or age of the scab lesions. From the commercial point of view, this would be, of course, an improper procedure; but since the epidemiology of the disease is our primary concern, the results of infection when stated in commercial terms do not measure adequately the variations in disease, though such an expression would indicate the relative predisposition of apple varieties to disease or the efficacy of spray schedules in preventing or halting the advance of an epidemic.

A significant refinement of the method we have used would be to make a careful count of the yield at picking time, in order to determine the ultimate percentage of infected fruits; and if at the same time a further careful grading could be performed with the infected fruits, measuring the quantity and size of the lesions, a still more accurate index of fruit disease would be obtained. But to do this has been

beyond our means, and we have had to limit our collection of fruit-infection data to the routine orchard examinations made while the fruit was still on the trees.

Scab on apple leaves may, under various conditions, result in a variety of types of injury to the tree, ranging from the mere discoloring of a few leaves to nearly complete defoliation. Such grossly visible evidences of the severity of the attack depend, however, to a very considerable degree upon the resistance of varieties, upon particular local conditions of soil and weather, and upon other factors that concern the tree as a whole more than the disease. Because of this, it is necessary in the measurement of a season's epidemic to ignore these very easily observed conditions and to place emphasis instead upon the actual extent of the leaf infection. Observations made with this limitation will serve in comparing the actual year-by-year success of the disease, and those influences which heighten the effect of the disease upon the tree will not enter into the problem.

For the purpose of making such leaf-infection measurements, we have developed the scales shown in Figures 2 and 3. From among a large number of infected leaves, readily distinguishable grades of disease have been selected, and careful measurements of them have been made by using an instrument called a planimeter, thus determining, first, the area of the entire leaf surface and, second, the exact area occupied by the scab infections. From these two measurements, the percentage of the area of each leaf occupied by scab lesions has been easily computed.

In finally selecting the examples chosen to make up the scale, it was desired, first, to have percentage values for each unit which could be handled by the observer with a minimum of trouble and, second, to have an interval between the increasing grades of infection sufficiently large to permit easy and certain separation of the leaves examined in the field into the grades represented by the standard.

If the reader were to measure each of the samples of the scale, he would find no one of them to be of exactly the value given in the diagram; but the variation in each case is small. If exactness of measurement had been the only aim in developing the scales, it would have been an easy task to make the standards conform exactly to the percentages given for them by making slight changes; but each of the standards is a careful tracing of an actual leaf with its actual infection, and this adds considerably to ease in usage, while the reproduction of the leaf in diagrammatic black and white masks its reality sufficiently to avoid confusion.

The two scales for measuring leaf infection by the scab disease are necessary in order to measure the two types of scab infection. For reasons which are not well understood, the fungus which causes the scab disease produces two distinct types of lesions on the leaves. These types, shown in Figure 4, are usually described as "diffuse" and "spot" infections. The latter is more commonly met with in Illinois, but the diffuse type is also abundant; and on a given leaf the lesions on the upper surface may be of one kind and those on the lower surface of the other kind. As may readily be seen in the illustration, the two are so different in appearance that a scale made for one would not fit the other.

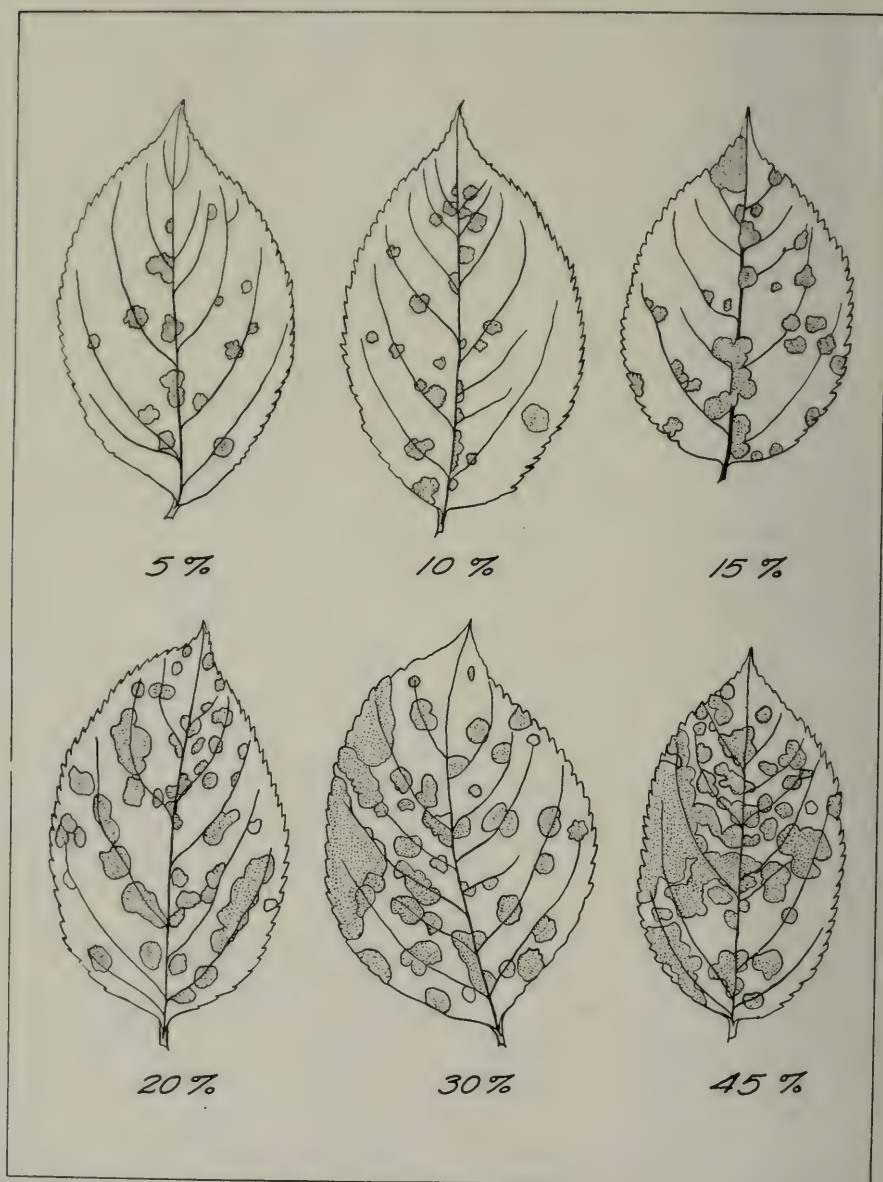


FIG. 2. SCALE FOR ESTIMATING THE INTENSITY OF THE SPOT TYPE OF SCAB ATTACK ON APPLE LEAVES

For each of the sample leaves in this scale, the total area of the spots has been determined and expressed as a percentage of its respective leaf area. By comparing infected leaves with these measured examples, the average leaf area occupied by scab lesions may be computed. See the text for details.

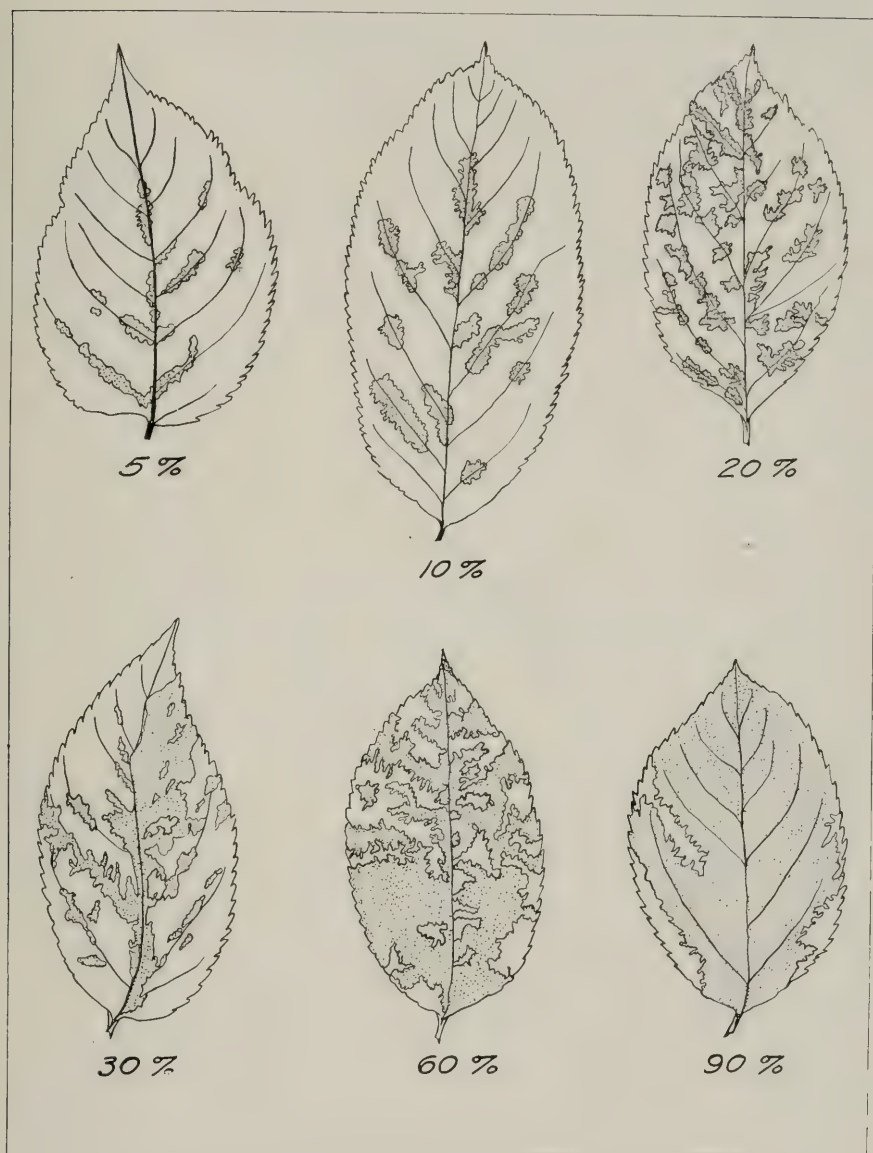


FIG. 3. SCALE FOR ESTIMATING THE INTENSITY OF THE DIFFUSE TYPE OF SCAB ATTACK ON APPLE LEAVES

The shaded area shown on each of the leaf diagrams represents scab lesions of the diffuse type illustrated in Fig. 4. This scale was prepared in the same way as the spot scale shown in Fig. 2 and is used in the manner described in the text.

In using these scales, the observer, walking from tree to tree in the orchard, is required to select a number of leaves at random from each tree, without regard to the presence or absence of infection, and to compare them, either then or immediately afterward, one by one with the standards of the scale. The results of one such comparison are shown on the sample field-record (page 418), but in practice the appearance of the record differs in that each leaf is recorded under its proper class by a penciled dot. In classifying the leaves, the rule is that a leaf is to be considered as belonging to the class of infection exemplified by the standard which it resembles most.

As an illustration, the data shown on the record sheet have been brought forward in the following:

Scale classes	0	5	10	15	20	30	45	60	Total
Class frequency, <i>i. e.</i> , number of examined leaves falling in each class.....	125	33	7	4	3	2	1	2	177
Class values.....	0	165	70	60	60	60	45	120	580

Of the 177 leaves examined, 125 were either not at all infected or else bore such small traces of disease that they could not be placed in any of the 7 measurable classes. There were also 33 leaves sufficiently diseased to be placed in the "5" class represented by the scale but still not infected heavily enough to merit placing in the "10" class. And in each of the succeeding higher classes of infection there were fewer leaves, as the table shows.

In determining the average amount of leaf infection shown by these observations, a series of items, labeled in the table above as "class values" have been computed by multiplying the percentage values of each of the classes by the frequency with which each class was represented in the sampling of leaves. The 125 leaves in the "0" class have a class-value, or infection value, of 0; those in the "5" class have a class value of 165; and those in the "10" class a value of 70. The sum of all the class values is 580; and this amount (which may be taken to represent the total percentage-area of scab-infected leaf surface shown by the entire leaf sample) is divided by 177 (the number of leaves in the sample) in order to obtain the average per cent. of scab-infected area per leaf. The result in this case is 3.28 per cent. This figure we assume to represent not only the leaves examined but also the average condition of all the leaves in the orchard, since those examined constituted a representative sample selected at random.

Data on Apple Scab

During the summers of each of the seven years beginning with 1922 and ending with 1928, data were secured which show both the prevalence and the intensity of the annual scab epidemics. A large number of apple plantations varying in size from single trees to exten-

sive commercial orchards with thousands of trees were visited and 494 usable records were taken. The total number of trees represented by all the data collected, from the first year to the last, is 132,943; and the number of counties appearing annually in the records averages 23, though the actual number has been as low as 4 (in 1925) and as high as 50 (in 1924). The average number of usable records secured per year stands at 70 and the average number of trees represented annually by these records is 18,991.

As appears from Table IV, in which the yearly indexes for prevalence and intensity have been added and averaged for the seven year term, the average prevalence of scab during the period covered by our observations has been 76.68 per cent., while the average proportion of fruit infected by the disease has been 16.56 per cent. and the index of average intensity for the leaf attack has been 4.92.

TABLE IV
PREVALENCE AND INTENSITY OF APPLE SCAB

Year	Prevalence	Intensity		Basis of data		
	Per-centage of trees having scab infection	Per-centage of apples infected by scab	Per-centage of leaf surface occupied by scab lesions	Num-ber of records	Num-ber of trees represented by the records	Num-ber of counties represented in the records
1922.....	93.00	37.45	8.13	243	18,965	49
1923.....	74.85	37.23	14.45	43	14,805	30
1924.....	63.98	24.52	6.65	83	48,865	50
1925.....	98.58	Trace	0.22	5	1,058	4
1926.....	16.32	0.01	0.22	16	9,511	11
1927.....	93.77	6.36	1.95	42	12,755	10
1928.....	96.32	10.36	2.84	62	26,984	8
Total.....				494	132,943	162
Averages.....	76.68	16.56	4.92	70	18,991	23

The variation from year to year in the scab epidemics is shown in Table IV by the annual indexes. Subject to the qualifications outlined briefly in the columns headed "Basis of data," these annual indexes, which represent both the prevalence of the disease and its intensity on fruit and on leaves, give comparable pictures of the disease as it occurred in each of the seven years.

In 1922 four observers secured 243 usable records, representing 18,965 trees. The analysis of these records indicate that 93 per cent. of the trees represented by them were infected by scab. As these records were drawn from apple plantations located in 49 counties well distributed over the State, this prevalence index may be considered as typifying the general prevalence of the disease that year throughout Illinois.

Upon the infected trees, the scab lesions were, as the records show, mainly on the fruit and the leaves. The actual extent of these infections on the infected trees is not shown in Table IV, since the data have been evaluated in the manner illustrated in Table I so as to show the extent of these infections as averages for all trees, whether infected or not. Hence, the field records taken in 1922 show that 37.45 per cent. of all the fruit borne on all trees represented by the records were infected by scab. In the same way, the leaf attack is given the average index, for all leaves on all the recorded trees, of 8.13, which is a concrete statement



FIG. 4. DIFFUSE LESIONS AND SPOT LESIONS PRODUCED BY SCAB ATTACK ON APPLE LEAVES

The leaf at the left bears lesions of the diffuse type, that at the right has typical spot lesions. Diffuse scab is usually found along the veins of leaves, while spot lesions are scattered irregularly over the leaf surface. These two types of lesions are usually found on separate leaves but occasionally occur on opposite sides of the same leaf. Their dissimilarity of appearance requires the use of the two measuring scales shown in Figs. 2 and 3.

of the percentage of leaf surface occupied by scab lesions. Since the number of records, the number of trees, and the counties in which these intensity records were secured are the same as for the prevalence record, the intensity indexes also indicate the intensity of the scab epidemic throughout the State.

The second year of the period, 1923, when 43 records representing 14,805 trees were secured in orchards located in 30 widely distributed counties, the prevalence index for scab stood at 74.85, the fruit intensity index at 37.23, and the leaf intensity index at 14.45. For the calculation

of these indexes, there were available only about one-sixth as many records as in 1922, but the average number of apple trees represented in each record in 1923 was more than four times as great as in 1922. The reason for this difference is found in the fact that in the later year more orchards of commercial size were seen, and there is a reflection of this in the prevalence indexes shown for the two years, that of the second year, less by 18.15 than that of the first, being attributable in some

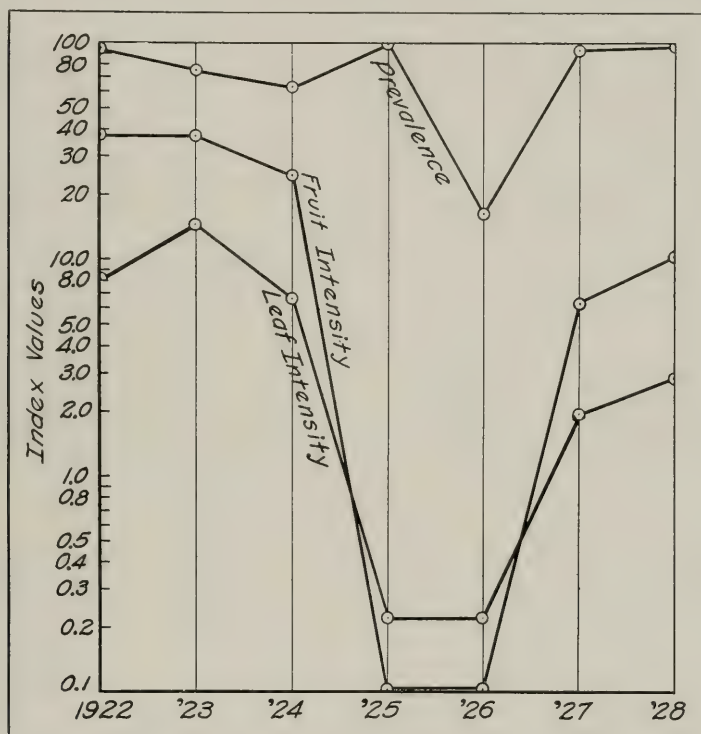


FIG. 5. TRENDS OF PREVALENCE AND INTENSITY SHOWN BY THE SCAB EPIDEMICS

The indexes of prevalence and intensity given in Table IV are plotted here by years against a logarithmic scale which makes the relative annual changes of each phase of the disease comparable with those of the other phases by the slope of the connecting lines. A discussion of this diagram is given in the text.

measure to the more general application of control measures in commercial plantations. The similarity in the intensity indexes for fruit for the two years appears, therefore, to indicate that 1923 was a worse scab year than 1922, and this finds considerable support in the very marked increase of the leaf intensity index from 8.13 in the former year to 14.45 in the latter.

The indexes both of prevalence and intensity for 1924, the third year of the survey, indicate a distinctly milder epidemic of scab than

occurred in the two preceding years. Based upon 83 records representing 48,865 apple trees and typifying the scab conditions prevailing in 50 of the 102 counties in the State, this season's observations, averaging 588 trees per record, are the most reliable of any thus far obtained. The decreasing trend exhibited by the several indexes consequently may be taken as an indication that in 1924 the growing season was distinctly less favorable to the scab disease than was the case in either of the two preceding years.

The indexes given for 1925 are the least reliable in Table IV. Circumstances over which we had no control so influenced the season's work as to reduce the number of records to 5 and the number of counties represented to 4, while the entire number of trees entering into the computation of the indexes was only a few over a thousand. The prevalence of scab, computed to be 98.58 per cent., may be unreasonably high in view of the exceptionally low intensity indexes, which are given as a "trace" (meaning that the actual amount was too small to be determined) for the fruit and 0.22 for the leaves. Yet, these indexes, when compared with a report to the United States Department of Agriculture made co-operatively by two observing agencies in Illinois, in which the prevalence is placed at 100 per cent., the reduction in apple yield at 0.5 per cent., and the injury to the foliage as nil, are seen to be in rather close agreement with the generally observed condition for the year. Consequently, the fact that 1925 stands out in Table IV as marking a very abrupt fall in the intensity of scab from the high levels of the preceding years should be regarded as typifying conditions, though the absolute index values are open to doubt. What appears to be a marked increase in prevalence may, in fact, have been a fault due to too scant data; but the high prevalence mentioned above as given by other observers suggests that both the prevalence and the intensity phases of the disease need not have followed the same trend.

In 1926, 16 records representing 11 counties and comprising a total of about 9,500 trees, most of which were in commercial plantations, gave a prevalence index for scab of 16.32. This is a great decrease from the index of the previous year and may be regarded as reflecting in a measure the exceptionally low intensity indexes of 1925. Of the 1926 intensity indexes, that for fruit disease increased to a measurable amount, stated in the table as 0.01 per cent., while the leaf disease index remained at the same level as in the preceding year. Though the greatest difference between 1925 and 1926 is the decrease in prevalence, the slight increase in fruit intensity in the latter year, coupled with the maintenance of the leaf intensity index, is indicative of the beginning of an increase in scab which ought, preventing circumstances being absent, to become more and more apparent in succeeding years.

In 1927, the prevalence of scab rose to 93.77 per cent., and this increase was accompanied by a distinct increase in the intensity of the attack, the fruit index reaching 6.36 and the leaf index 1.95. The 42 records entering into the computation of the indexes were taken in 10 counties located mainly in the central and southern fruit sections of the State, and a total of 12,755 trees, mostly in well-cared-for orchards, were represented in the data. A general increase over the previous year, both in prevalence and intensity, was decidedly apparent.

For the final year, 1928, the characters of the scab epidemic were shown by 62 records drawn from 8 central and southern counties, and in the computation of the indexes there was entered a total of 26,984 apple trees. The prevalence of scab, determined as 96.32 per cent., increased somewhat over 1927 and there was an accompanying but relatively greater increase in the intensity indexes, that for the fruit attack being 10.36 and that for the leaf attack being 2.84.

The trends of prevalence and intensity of the scab epidemics from year to year for the entire period of observation are shown graphically in Figure 5. The vertical scale in this graph is arranged in a manner such that the slant of the trend lines expresses the relative rate of increase or decrease of the prevalence and the intensity indexes, regardless of the actual numerical values they may have.

An examination of this diagram suggests that during the first three years scab was maintaining itself at a rather high level, possibly the highest it could attain under the climatic and cultural conditions prevailing in Illinois, and was not being subjected to circumstances resulting in great variation in the prevalence or intensity of its annual epidemics. How long this high level of disease had been maintained can not be determined from the data at hand; but, as the graph shows, it came to an abrupt end in 1925. Though the prevalence of scab increased in that year more than it had declined in the two preceding years, the intensity of the attack upon both fruit and leaves fell to exceedingly low levels. Their drop is so sharp as to outweigh by many times the relatively small increase in prevalence.

The effect of the great scab decline of 1925 remains apparent in 1926. Perhaps because the amount of infective materials produced in 1925 was very small, the prevalence of scab dropped in 1926 to the lowest point of which we have record. But the fact that the low levels of the fruit and leaf intensities reached in 1925 were at least maintained in 1926 probably is a rather definite indication that the conditions prevailing in 1926 tended to favor, rather than inhibit, the disease: otherwise, a further decline should have occurred. This view is also justified by the large increases in prevalence and intensity in the last two years shown on the graph. In 1927 all phases of the disease increased very greatly, but, except for prevalence, the indexes did not reach the high levels common before 1925. Though a much smaller increase occurred in 1928, it served to bring the scab indexes still nearer the level of the first years. The trend of scab since 1925 has been upward, and it is reasonable to suppose that it will continue upward until the usual levels are reached, unless another unfavorable year such as 1925 halts its advance.

APPLE BLOTCH

Caused by *Phyllosticta solitaria* E. & E.

Blotch of apples, in contrast with scab, is limited in its distribution practically to North America, and in Illinois it is confined, at least as a destructive disease, to the southern two-thirds of the State. Within this region it is often very serious. Fruit is attacked and defaced to such an extent as to be unmarketable; leaves are spotted more or less

severely and the yielding abilities of the attacked trees lessened thereby year after year; and the young wood, particularly the twigs, is subject to infection, the resulting cankers remaining for three or more years to provide new infective material and to contribute to the decreasing ability of the trees to yield. There are, of course, other frequent types of infection, such as that on the bud scales, on the petioles of leaves, and on the stems of the fruit, but these are intrinsically of little significance, though it is true that the lesions on the lowest parts of the petioles often extend into the twigs and cause a large proportion of the cankers found at the nodes of twigs.

In the measurement of the annual blotch epidemics in Illinois, the prevalence of the disease and the intensity of its attack have, as with apple scab, been recognized as distinct phases. Prevalence has been determined by counting, in each plantation examined, the number of infected trees, regardless of the types or kinds of infection present on the trees, and expressing this number as a percentage of the entire number of trees in the plantation. Such a percentage, computed in the manner previously described and applying to all the blotch-infested orchards examined during a year, is regarded as an index of the general prevalence of blotch for the year. As such, it may be compared with similar indexes for other years.

The intensity of blotch attack cannot be measured as a single unit, because the variations in the epidemic from one year to another tend to emphasize sometimes one, sometimes another, of the various modes of attack; and there are also remarkable varietal differences among apples with respect to their susceptibility to one or more forms of the disease. Blotch injury on diseased trees is, however, most serious on the fruit, the leaves, and the twigs. In each of these types of attack a distinct form of intensity is represented, and each type must be measured separately. Thus far, we have gauged fruit infection only in terms of infected fruits; that is, the percentage of infected apples has been determined by careful counts, but no attempt has been made to record the number of blotch lesions per apple. Similarly, our measurement of the intensity of twig blotch has been limited to a determination of the percentage of infected twigs per tree, without attempting to specify either the number, the age, or the extent of the cankers.

For blotch on the leaves, however, a more accurate means of measurement has been employed. The diagram shown in Figure 6 constitutes a scale by which the intensity of leaf attack can be determined as the percentage of leaf area occupied by blotch lesions. In the construction of this scale, just as in the making of the scab scale, a large number of leaves showing various degrees of infection were placed in series and from among them representative samples were selected, which graded from light to heavy by readily distinguishable intervals. Careful tracings were made of these leaves, and of the spots borne by them, and the area of each of these standard leaves was determined carefully with a planimeter. To determine the area occupied by the blotch infections, it was necessary first to find the average area of a spot, since the individual spot is too small to be measured accurately. This average was obtained by tracing contiguously the magnified outlines of a large number of

spots, measuring the area covered by them all, and dividing this area equally among them after reducing it to its actual, or unmagnified, size.

The percentage of the area of each of the leaves serving as standards in the scale occupied by the blotch spots could then be very closely approximated by first counting the number of infections on each leaf, multiplying the average spot area by these numbers, and dividing the

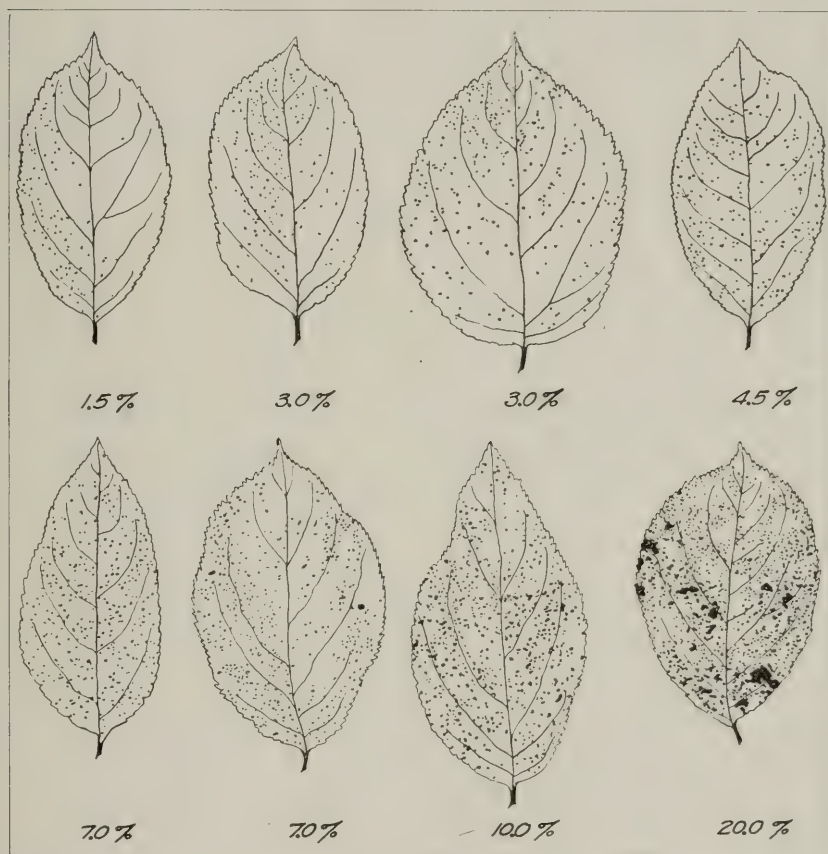


FIG. 6. SCALE FOR ESTIMATING THE INTENSITY OF THE ATTACK OF BLOTCH ON APPLE LEAVES

The figures given below each leaf diagram express the percentage of the area of each leaf occupied by blotch spots. The scale is used in the same way as the scab scales.

total spot areas so obtained for each leaf by the respective leaf areas. This process is, of course, subject to an error arising from a random sampling of spots in selecting the standard leaves, but even in the lesser grades of infection the number of spots is so large (it is exactly 100 in the first standard leaf) as to reduce this error to an insignificant point.

For two of the grades used in the scale, two standard leaves have been supplied. The reason for this is that, with such small spots as those made by blotch and with the small percentage intervals that must be used to gauge blotch infection on leaves, the different appearance of large and small leaves with the same percentage of occupied area is often misleading to the eye, since the tendency in visual appraising is to emphasize the number, rather than the combined areas, of the spots. With light infections this danger is minimized by the fact that the intervals between the standards of the scale are smaller, while with heavy infections the greater intervals between standards, which is necessary for accurate classification, tend to lessen its occurrence.

The manner in which the leaf blotch scale is used in measuring the success of the blotch disease is similar in every respect to the method previously described in detail for the scab scale.

Data on Blotch

In determining the prevalence and intensity of the blotch disease of apples in Illinois, a total of 258 orchard records have been collected, and in securing them a total of 219,574 trees have been considered. Though the number of records, and the number of trees represented by them, has varied considerably from year to year, as may be seen in Table V, the average number of records per year was 36 and the average number of trees considered per year was 31,367. The extent of the territory in which the records were taken has varied also, the maximum number of counties represented in any one year being 38 in 1924 and the minimum number being 2 in 1925; but the average number of counties per year has been 18.

Table V shows the results of the survey of blotch. Over the 7 years of the survey term, the average prevalence of blotch is shown to be 72.33 per cent., while the average intensity of its attack is 18.09 per cent. for the fruit phase, 27.65 for the twig phase, and 1.19 for the leaf phase. These figures may be taken to mean that, year after year, the blotch disease attacks an average of 72 per cent. of the apple trees in the blotch infested orchards of Illinois, that in these same orchards it infects to an undetermined extent 18 per cent. of all the apples produced and 27 per cent. of all the young apple wood, and that the area occupied by its leaf lesions amounts to 1.2 per cent. of all the leaf area of all these trees.

The variations in all phases of the blotch epidemics, as they occurred from year to year, are also shown in Table V by the comparative sizes of the annual indexes given for each of the measured modes of attack. The indexes for 1922, computed from 68 records representing 17,781 trees distributed among 33 counties, give blotch a prevalence of 53.03 per cent., while the percentage of diseased fruit amounted to 41.36, the percentage of diseased twigs to 10.49, and the diseased leaf area 2.56 per cent.

In 1923, data computed from 54 records representing more than 75,000 trees located in 28 counties, showed a rise in blotch prevalence to 89.14 per cent., but this increase in prevalence was accompanied by a

fall in the intensity of the fruit attack to 32.15 per cent., a decrease of 9.21 from the index of the preceding year. The rise in prevalence was accompanied, however, by a rise in the intensity of twig attack to 81.29 per cent. and in the intensity of leaf attack to 3.89 per cent.

In 1924, blotch prevalence remained very high, the index of 87.68, which was computed from 54 records derived from 38 counties and representing 93,329 trees, being only 1.46 less than that for 1923. The intensity of the disease was, however, consistently low, the attack on fruit having an index of only 3.89, that on the twigs an index of 8.41, and that on the leaves an index too small to be recorded other than as a trace.

Blotch conditions in 1925 are represented by a very small number of records, which exemplify the attack on only 238 trees parceled be-

TABLE V
PREVALENCE AND INTENSITY OF APPLE BLOTCH

Year	Prevalence	Intensity			Basis of data		
	Per-centage of trees having blotch infection	Per-centage of apples infected by blotch	Per-centage of twigs infected by blotch	Per-centage of leaf area occupied by blotch lesions	Num-ber of records	Num-ber of trees represented by the records	Num-ber of counties represented in the records
1922.....	53.03	41.36	10.49	2.56	68	17,781	33
1923.....	89.14	32.15	81.29	3.89	54	75,625	28
1924.....	87.68	3.89	8.41	trace	54	93,329	38
1925.....	100.00	9.09	54.54	1.93	3	238	2
1926.....	46.67	12.48		0.01	21	11,622	14
1927.....	71.87	18.34	7.59	trace	31	11,207	10
1928.....	57.92	9.37	3.59	trace	27	9,772	7
Total.....					258	219,574	132
Averages.....	72.33	18.09	27.65	1.19	36	31,367	18

tween two counties. The prevalence index for the disease, exactly 100 per cent., calculated from these records is undoubtedly too high and should therefore be regarded as an expression of a prevalence at most no greater than in previous years. The intensity indexes are also subject to the same limitations. Consequently the index of fruit attack, designated as 9.09 per cent., and of leaf disease, shown in Table V as 1.93 per cent., should be considered not as indicating increases over the preceding year but as showing a continuation of the former year's low values. The rather high index of twig attack, 54.54 per cent., possibly peculiar to the plantations from which the data were secured, serves only to illustrate the ability of blotch to perpetuate itself in this form for several years.

In 1926 the indexes were computed from 21 records drawn from 14 counties and representing, in all, 11,622 trees. The prevalence indicated by these records is 46.67 per cent., which is probably somewhat of a decrease from 1925. The larger index for the fruit attack, 12.48 per cent., is undoubtedly an indication of blotch recrudescence following the two previous unfavorable years, though this is borne out only to a relatively slight extent by the leaf disease index of 0.01 per cent. Data on the twig attack are lacking for this year.

For 1927, 31 records made in 10 counties and representing 11,207 apple trees gave a prevalence of 71.87 per cent., which serves to indicate that blotch had regained much of the ground lost in 1924 and 1925; and an increase of the fruit intensity index to 18.34 per cent. bears out this indication. The value of the index for twig disease, 7.59 per cent., is, however, not greatly different from that of 1924.

In 1928 the prevalence of blotch, as indicated by 27 records obtained from 7 counties and representing 9,772 trees, fell to 57.92 per cent. In keeping with this are the noticeable decreases shown by the fruit and twig disease indexes, the former being 9.37 per cent. and the latter 3.59 per cent. The very small amount of leaf blotch is expressible, as in the previous year, only as a trace.

Subject to the limitations in data pointed out above, the trends of both the prevalence and the intensity of the apple blotch epidemics from year to year through the period covered by our survey are shown graphically in Figure 7. The general trend of the disease has been downward, and the changes from one year to another have, on the whole, been rather large. From a fairly high point in 1922, blotch increased considerably in 1923, and fell to a low point in 1924. The following year, 1925, it regained a considerable part of what it lost in 1924, and immediately thereafter, 1926, began a downward movement, interrupted by a slight rise in 1927, that furnished the low indexes of 1928. The course which the disease may follow in 1929 and later cannot be anticipated from the diagram, though the suggestion of the trends shown there is that it will continue downward.

By examining Figure 7 more closely, one may see that a rather striking parallel exists in the year to year trends exhibited by the various blotch indexes. The prevalence index stands at a relatively high point throughout, but its general level during the first four years was distinctly higher than during the last three years. The indexes for leaf and twig blotch appear to conform to this generalization; and it is worthy of note, in particular, that the upward trend in prevalence from 1922 to 1923 is reflected by similar though unequal trends in leaf and twig infection. The very slight decrease in prevalence from 1923 to 1924 appears also, in a greatly magnified degree, in the sharp decrease exhibited by the fruit, leaf, and twig infections, while the prevalence increase in 1925 is reflected also in the increased indexes of disease intensity. The fall in prevalence shown for 1926 was accompanied by a fall in the intensity of leaf disease and probably also of twig disease, though there is no adequate data to support the contention. For the slight rising and

falling of blotch prevalence in 1927 and 1928, respectively, the fruit intensity index is seen to rise and fall, the twig intensity index to fall in 1928 to a point lower than it held in 1927, and the leaf intensity index to remain so low in both years as to be unmeasurable.

In general, it appears that the trend of prevalence exhibited by apple blotch from year to year is reflected in a distinctly magnified degree by the trends of each of the modes of blotch attack, but there is no lagging behind of any phase of the disease. It should be noted, how-

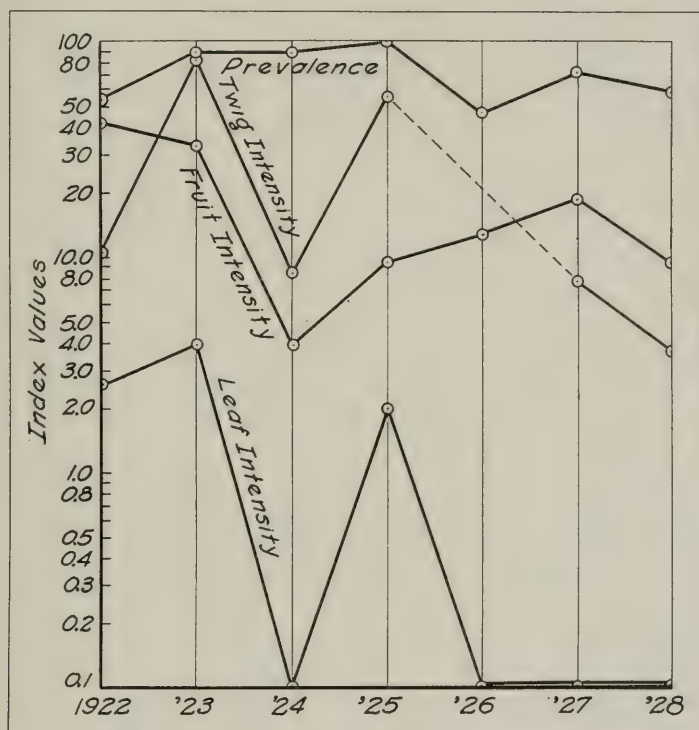


FIG. 7. TRENDS OF PREVALENCE AND INTENSITY SHOWN BY THE BLOTCH EPIDEMICS

The changes from year to year shown by the measured types of intensity are much greater than the changes in prevalence. Data for twig intensity in 1926 are lacking.

ever, that the intensity of blotch on the fruit, at least so far as it is expressed in our data, may at times move entirely independently of the other phases of the disease. Thus, in 1923, when the other trends had moved upward, the fruit infection trend was unmistakably downward; and in 1926, as the others moved sharply downward, that for fruit infection moved upward.

APPLE BLACK-ROT

Caused by *Physalospora malorum* (Pk.) Shear

The black-rot disease, known to occur widely in Europe, in South Africa, and in Canada, as well as throughout the United States, is one of the most common, though not usually the most serious, of apple diseases in Illinois. It ranges throughout the State and is found, in one or another of its forms, in practically every orchard. The most important injury resulting from it is the fruit-rot from which it is named. Generally, this rot is not of great importance, unless some predisposing factor such as codling moth injury provides unusually good conditions for its development. The canker form of black-rot does permanent damage to apple trees, but the fungus which causes the disease is known to be a weak parasite, able to gain access to the woody parts of the tree only through injuries already accomplished by more active diseases such as fire-blight.

Upon apple leaves, the black-rot disease appears as a spot which, because of its characteristically zonal markings, is commonly known as "frog-eye." After being killed by the black-rot fungus, the leaf tissues of these spots often are invaded by other fungi, and it has been our experience in Illinois that these secondary invaders are found in the lesions more often than the black-rot fungus. Hence, in measuring the extent of black-rot on leaves we have counted all "frog-eye" spotting as black-rot, regardless of the identity of the fungus actually found on the spots by microscopic examination.

In measuring black-rot epidemics, the statistical phases taken into consideration have been prevalence, intensity of fruit attack, the quantity of twigs and woody parts infected, and the percentage of leaf area occupied by the frog-eye spots. Prevalence, as with other diseases, is expressed as the percentage obtained by comparing the number of infected trees with the total number; and the intensity of both the fruit and twig infections is expressed as the percentage of these individual parts infected by the disease. No attempt has been made to measure further the severity of the infection on the individual apple or twig. With the fruit, however, it should be stated that only the apples on the trees have been counted, as the infection of fallen fruit, though one of the most common causes of decay, is nearly always secondary to injury by codling moth larvae.

In measuring the intensity of black-rot on leaves, we have used the scale shown in Figure 8. The units of the scale were selected and measured, and the scale itself has been used, in the manner already described in detail in the discussions of scab and blotch. The very small leaf-area values shown in Table VI and discussed in succeeding paragraphs seem inconsistent with the relatively large values shown by the standards in the scale, but it must be remembered in this connection that the scale itself serves only to measure the infected leaves, which often constitute only a small portion of a leaf sample, and that the total area occupied by lesions, which is obtained by using the scale, is parceled evenly among all the leaves of the sample.

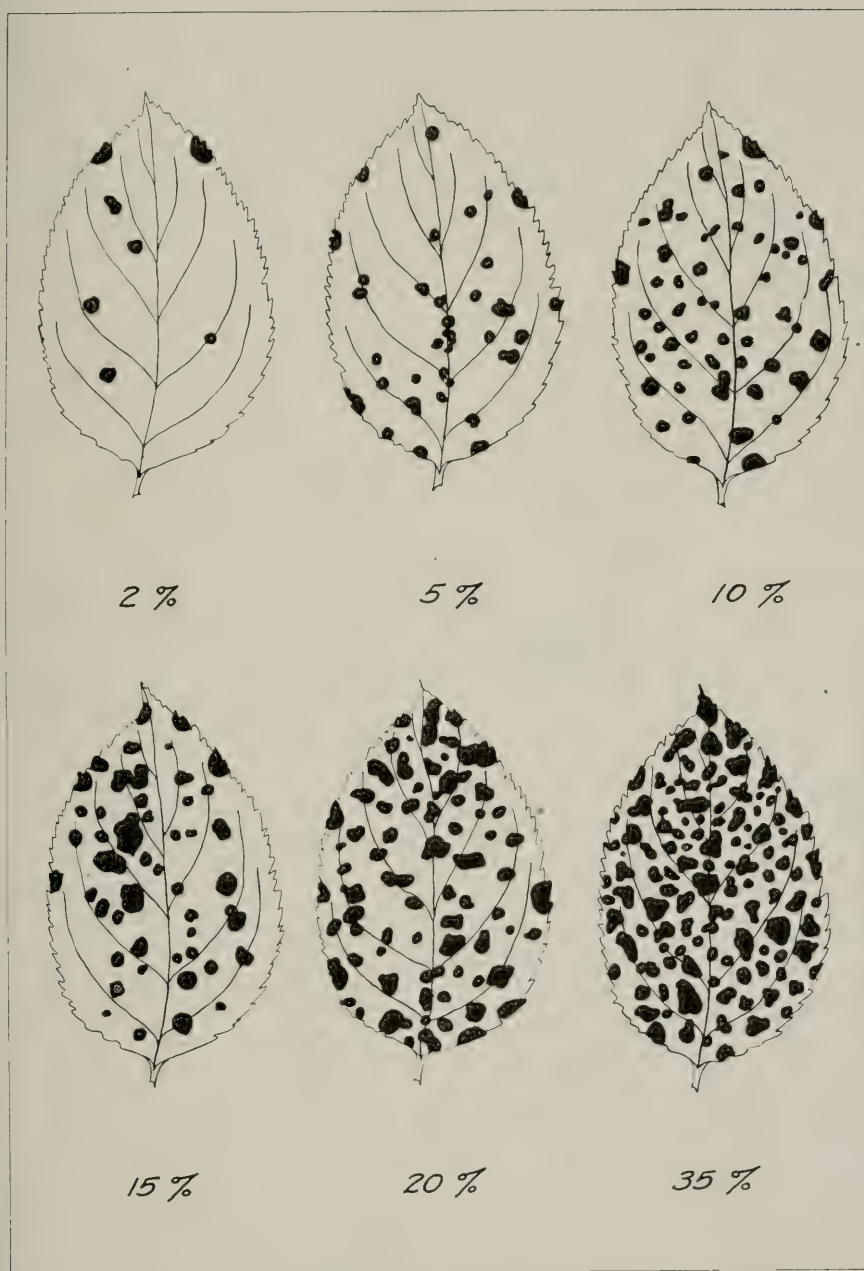


FIG. 8. SCALE FOR ESTIMATING THE INTENSITY OF "FROG-EYE" SPOTS, THE MANIFESTATION OF BLACK-ROT ATTACK, ON APPLE LEAVES

This scale is used, in the manner described in detail in the discussion of apple scab.

Data on Black-rot

A total of 311 records have been taken on black-rot during the course of our survey, and the data contained in these records present the state of the disease on 115,729 apple trees. As may be seen in Table VI, which gives the annual indexes of prevalence and intensity for black-rot, the number of records taken in any one year has ranged from a maximum of 99 in 1922 to a minimum of 2 in 1925, while the average number per year has been 44. The number of trees represented by the sets of annual records has varied also, ranging from a maximum of 26,452 in 1927 to a minimum of 198 in 1925, and the average yearly number has been a little over 16,500. The average number of counties represented in the yearly records is 15, but the actual number per year has ranged from a minimum of 1 in 1925 to a maximum of 32 in 1922.

TABLE VI
PREVALENCE AND INTENSITY OF APPLE BLACK-ROT

Year	Prevalence	Intensity			Basis of data		
	Per-centage of trees having black-rot infection	Per-centage of apples infected by black-rot	Per-centage of twigs infected by black-rot	Percent-age of leaf area occupied by black-rot lesions	Num-ber of records	Num-ber of trees represented by the records	Num-ber of counties represented in the records
1922.....	65.64	0.80	1.10	0.36	99	7,893	32
1923.....	55.54	0.45	0.45	0.18	13	11,059	10
1924.....	82.65	1.05	2.26	0.52	36	25,281	28
1925.....	91.41	trace	trace	1.09	2	198	1
1926.....	91.57	0.17	0.004	0.16	54	20,717	18
1927.....	100.00	0.01	0	0.15	63	26,452	13
1928.....	100.00	0.01	trace	0.05	44	24,129	8
Total.....					311	115,729	110
Averages.....	83.83	0.35	0.54	0.36	44	16,532	15

The data obtained in the survey, as summarized in Table IV, show that during the period 1922-1928, the black-rot disease of apples has had the high average annual prevalence of 83.83 per cent., but that its intensity during this period, as measured by the occurrence of infection on fruit, on twigs, and on leaves, has been very light. The infected fruit has averaged but 0.35 per cent.; only 0.54 per cent. of the twigs have borne black-rot cankers, and the leaf area has been reduced only 0.36 per cent.

The same condition can be seen in the data given for individual years. In 1922, with prevalence at the relatively low point of 65.64, 0.8 per cent. of the fruit in the infested orchards examined was infected, 1.1 per cent. of the twigs were cankered, and the leaf area was reduced

by frog-eye spots only to the extent of 0.36 per cent. In 1923, when the prevalence of black-rot, computed as 55.54 per cent., was at the lowest point observed by us, all forms of black-rot attack were low also, only 0.45 per cent. of both the fruit and twigs being diseased and 0.18 per cent. of the leaf area occupied by lesions.

The sudden rise of prevalence in 1924 to 82.65 per cent. was accompanied by increases in the indexes of all three types of attack, the computations made with the data for the year giving an average of 1.05 per cent. of black-rot infected fruit, 2.26 per cent. of cankered twigs, and 0.52 per cent. of leaf area occupied by frog-eye spots.

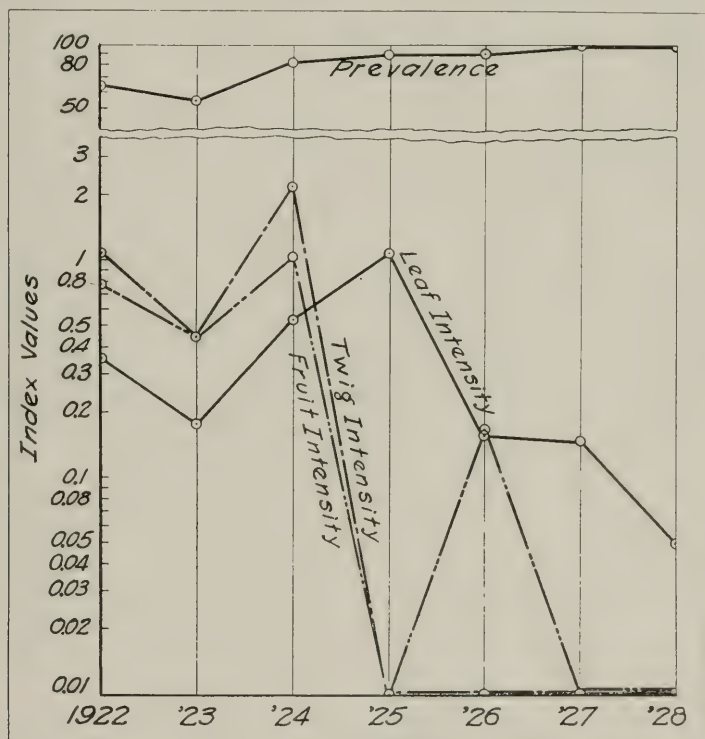


FIG. 9. TRENDS OF PREVALENCE AND INTENSITY SHOWN BY THE BLACK-ROT EPIDEMICS

Prior to 1925, prevalence and the three measured forms of intensity were high, and their changes from year to year were uniform in direction. In 1925, however, an upward movement in prevalence and leaf intensity was accompanied by sharp falls in both twig and fruit intensities. Subsequent to 1925, prevalence continued to increase, but there was a general falling off in all intensities.

This is in decided contrast with the conditions indicated by our relatively small amount of data for 1925. Though in this year the prevalence index rose to 91.41 per cent., the rise was accompanied by rather steep falls in two types of black-rot attack, the percentage of rot-infected fruit and cankered twigs sinking to amounts too small to

estimate. There was, however, a rise in the leaf infection index to 1.09, the highest point in our record. Respecting the value of these indexes, it may be stated that though the number of observation, and of trees, upon which the indexes are based are very small, the relative state of the disease expressed by them is in accord with the conditions generally observed to have prevailed that year, although it is possible that the actual increase in black-rot leaf-spot is magnified somewhat in the index.

In 1926, the prevalence index rose very slightly to 91.57, and there were corresponding slight increases in the intensity indexes representing the black-rot attack on fruit and on twigs, the former being 0.17 and the latter 0.004. The index of leaf-attack, however, fell to the lowest point recorded in our observations up to that year.

Continuing the tendency to increase shown during three preceding years, the prevalence index rose in 1927 to 100 per cent.; but all the intensity indexes moved downward, that for fruit-rot to 0.01 per cent., that for twig cankers essentially to 0, and that for leaf spot to 0.15.

In 1928, the high prevalence of 1927 was maintained, and the downward movement of the intensity indexes was continued to 0.01 per cent. for fruit-rot, an inestimable trace for twig canker, and 0.05 per cent. for leaf spot.

The trends of prevalence and of the intensity of the three important forms of black-rot attack on apple are shown graphically in Figure 9. In this figure, the portion of the graph which would ordinarily be seen between the wavy lines has been omitted in order to bring the high prevalence line into closer comparison with the low intensity lines. From this graph, it may readily be seen that only from 1922 to 1923 and from 1923 to 1924 is there a complete parallelism among the prevalence and the three intensity curves. In 1923 all swing downward from the previous year, and in 1924 they swing upward. The rate of change is not, however, equal in any two cases. The upward trend of prevalence and leaf infection from 1924 to 1925 contrasts sharply with the steep fall of the twig and fruit infections; but the continued rise of prevalence from that year on is coupled with falling leaf intensity and low twig and fruit intensities.

APPLE FIRE-BLIGHT

Caused by *Bacillus amylovorus* (Burr.) Trev.

Fire-blight, like apple scab, occurs throughout Illinois; and just as scab is the most feared of apple diseases because of its ability to ruin a season's crop, so fire-blight furnishes the greatest threat to the continued existence and productivity of apple orchards. There is no part of an apple tree that cannot become blighted. With the appearance of the blossoms in early spring, fire-blight begins its destructive work, and as the season progresses new forms of attack may constantly be observed to appear. The year-round nature of the disease is well illustrated by the very generally recognized types of attack, commonly known as blossom-blight, twig-blight, leaf-blight, fruit-blight, cankerous blight of the limbs and trunk, and collar-blight at the base of the tree. Seasonal phases of fire-blight, such as blossom-, twig-, and fruit-blight, constitute

the epidemic aspects of the disease, and it is these which cause the annual reductions in yield, while the cankerous phases, represented by limb-, trunk-, and collar-blight, are permanent forms which constitute continual hazards in orchard maintenance.

In the measurement of epidemic fire-blight we have thus far limited ourselves to acquiring data on two phases only, prevalence and twig-blight. As a measure of the intensity of the annual blight epidemics an index of twig-blight serves as the best total statement obtainable, unless more exacting observations are made on individual phases than we have been able to undertake. Our twig-blight count includes fruit spurs which show evidence of blossom-blight, leaf-blight, or spur-blight, as well as the real twig-blight which commonly occurs a little later in the season. It is, therefore, a comprehensive measure of all epidemic phases of the disease; and the data presented below should be accepted in that sense.

Data on Fire-blight

In the course of our survey, 373 records have been made of the occurrence of fire-blight in apple plantations. These records typify the condition of the disease with respect to a total of 169,346 trees, or an average of 24,192 trees for each year's observations; and for the average year, the records show conditions prevailing in 23 counties. As may be seen in Table VII, the largest number of records secured in any one year was 105, in 1922, while the smallest number was 10, secured in 1927. The territory represented by these records has varied also, 41 counties furnishing the 1924 records and 7 counties the records for 1927; and the number of apple trees from which the recorded data was collected has varied from a maximum of 42,567 in 1924 to a minimum of 9,583 in 1927.

TABLE VII
PREVALENCE AND INTENSITY OF APPLE BLIGHT

Year	Prevalence	Intensity	Basis of data		
	Percentage of trees having blight infection	Percentage of twigs infected by blight	Number of records	Number of trees represented by the records	Number of counties represented in the records
1922.....	42.64	1.86	105	13,202	38
1923.....	72.85	9.61	58	36,119	32
1924.....	65.41	10.69	77	42,567	41
1925.....	59.85	4.76	19	25,132	9
1926.....	58.89	4.49	60	25,919	28
1927.....	21.04	0.09	10	9,583	7
1928.....	81.01	3.05	44	16,824	9
Total.....			373	169,346	164
Averages.....	57.38	4.93	53	24,192	23

Variable as the quantity of the yearly records is, they are in the main representative of fire-blight conditions during the past seven years. The average prevalence of the disease, secured by giving each year's observations equal weight and dividing the sum of prevalence indexes for the period equally among the years, is shown in Table VII to be 57.38 per cent., and the average intensity of the fire-blight attack, expressed in terms of blighted twigs and spurs, is 4.93 per cent.

The individual years, however, often show considerable variations from the average. The prevalence of fire-blight in 1922, when 105 records were secured in 38 counties, was 42.64 per cent. in a total of 13,202 apple trees, less by 14.74 per cent. than the average, and the

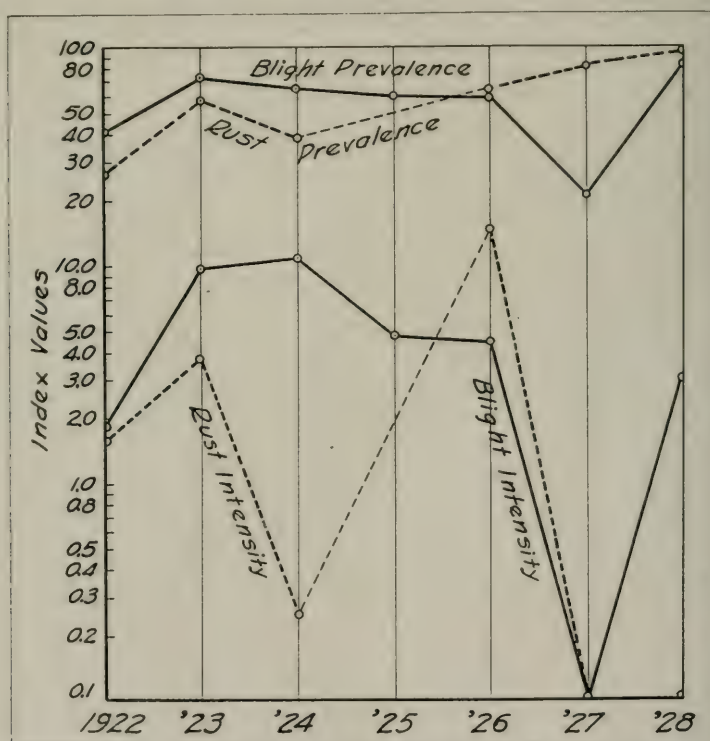


FIG. 10. TRENDS OF PREVALENCE AND INTENSITY SHOWN BY THE RUST AND FIRE-BLIGHT EPIDEMICS

The annual fluctuations illustrated in this figure are discussed in the text. Data are lacking for the 1925 rust epidemic.

intensity of the attack, estimated at 1.86 per cent., was 3.07 per cent. less than the average.

In 1923, on the other hand, 58 records secured from apple-tree plantations distributed among 32 counties, showed a fire-blight prevalence of 72.85 per cent. among a total of 36,119 trees—15.47 points above the average condition—and an intensity of 9.61 per cent. for twig-

blight, this intensity being higher by 4.68 per cent. than the average. In 1924, when 77 records taken in 41 counties showed a prevalence of 65.41 per cent. among 42,567 trees and an intensity of 10.69 per cent., the disease exceeded its average conditions by 8.03 and 5.76 per cent., respectively. This excessively high fire-blight condition was maintained to a lesser extent in 1925 when, on the basis of 19 records, the prevalence of the disease was shown to be 59.85 per cent. among 25,132 trees, or 2.47 points above the average; but in this year the intensity of fire-blight dropped to 4.76 per cent., or 0.17 point below the average. On the basis of 60 observations taken in 28 counties, the prevalence of blight in 1926 was shown to be 1.51 points above the average by the index for the year, which was computed to be 58.89 per cent. among 25,919 trees. The intensity of the attack, however, was 0.44 of a point less than the average, or 4.49 per cent.

The tendency of fire-blight to decrease, which was more or less apparent in the years from 1923 to 1926, appeared in its full extent in 1927. In that year 10 observations drawn from 7 counties indicated a prevalence of 21.04 per cent. among 9,583 trees and an accompanying intensity of 0.09 per cent. for twig-blight, these indexes being respectively 36.34 and 4.84 per cent. below the average conditions.

In 1928, there was a great recrudescence of blight, its prevalence, as indicated by 44 records made in 9 counties, being 81.01 per cent. among 16,824 trees; but the intensity of twig-blight, though it rose to 3.05 per cent., still remained at 1.88 points below the average.

The trends of prevalence and intensity of fire-blight are shown graphically in Figure 10 by the solid lines. The arrangement of the vertical scale of the graph is such as to make the changes from one year to another comparable in terms of the slope of the lines. It is readily seen that the intensity of blight attack has varied much more, proportionately, than its prevalence. With the single exception of the change from 1923 to 1924, when the prevalence trend fell and the intensity trend rose, the direction of both trend lines is the same for every year. And it is notable also that in every case the movement shown in the prevalence curve is magnified, in the intensity curve, to an extent accurately indicated by the relatively greater steepness of the year-to-year sections of the intensity curve.

APPLE RUST

Caused by *Gymnosporangium juniperi-virginianae* (Schw.) Sw.

Among the apple tree diseases occurring in Illinois, apple rust is distinctive because it is purely annual in occurrence on apple trees, and for this reason it is the only one of the apple diseases that can be classed as strictly epidemic. The destruction caused by it is limited to the fruit and leaves, and with the falling of the leaves and harvesting of the fruit it is entirely removed from the trees. The rust epidemic of any one year is, therefore, entirely separate from the epidemics of the preceding and following years. Since the fungus which causes the disease produces no permanent lesions upon the apple tree, it depends for its annual propagation upon its ability to accomplish a portion of its development upon another host, the cedar. So specialized are the

habits of the fungus that the spores developed by it upon the apple tree are wholly unable to reinfect apple trees. They are, however, virulent on cedars, and the rust epidemics consequently develop anew each year from the infective material supplied by the "cedar-rust" phase of the disease.

Since it is annually dependent entirely upon cedar trees for its propagation apple rust is not so widely or generally distributed in Illinois as the other epidemic diseases of apples but is limited in its occurrence to regions in which cedars are relatively common and grow in close proximity with the orchards. Nevertheless, the extent of its range includes the entire state.

In measuring the annual rust epidemics, we have limited the accumulation of data to two phases of the disease. These are prevalence and the intensity of rust attack on the leaves, prevalence being, as with other diseases, expressed as the percentage of infected trees found in rust-infested orchards and leaf intensity as the approximate percentage of leaf area occupied by the rust spots as measured by the area-scale given previously for the spot type of scab, as this scale approximates with reasonable closeness the rust-spot condition.

Data on Apple Rust

Satisfactory data on apple rust were secured for each of the years except 1925 included in the period of our survey. The less extensive distribution of the disease is seen in the fact that the total number of records of the disease is just 116, whereas 494 scab records were secured in the same period. The total number of trees from which these rust records were derived is 53,377. The average number of records per year was 19, and the average number of trees per year was 8,896, the data for each year representing, on an average, the rust conditions in 11 counties.

As is shown in Table VIII, the computations made with the accumulated apple rust data indicate that in rust infested orchards the average yearly prevalence has been 61.96 per cent., while the severity of the attack has been equivalent to a rust occupation of 3.38 per cent. of the leaf area produced by all trees in the orchards.

The exact condition of each year with respect to the rust attack is also shown in Table VIII. For 1922, 16 records derived from 14 counties indicate a rust prevalence of 26.29 per cent. among 3,503 apple trees, with an accompanying intensity of foliage disease amounting to 1.57 per cent. of leaf area. In 1923, when 14 records were obtained in 8 counties, the prevalence of rust was 57.29 per cent. in 6,210 trees, and the intensity of the leaf attack amounted to 3.7 per cent. of the leaf areas of these trees. In 1924, the 29 records secured in 23 counties indicated the prevalence of rust to be 38.77 per cent. in 23,056 trees, with a leaf-area occupation of 0.25 per cent. Data were not secured for 1925, but in 1926 the prevalence of rust, as shown by 12 records taken in 9 counties, amounted to 72.51 per cent. among 2,445 trees, while the intensity of the leaf attack is given the astonishingly high index of 14.63. In 1927, the prevalence of rust rose still further, the 23 records taken that year giving a prevalence index of 81.22 per cent. among

6,998 trees; but the intensity index dropped to 0.06 per cent., the lowest among our records. Again in 1928, prevalence increased, the index derived from 22 records taken in 7 counties being 95.72 per cent. for 11,165 trees; but the intensity of the rust attack was, nevertheless, quite light, the index of leaf-area occupation by rust spots being only 0.1 per cent.

The trends of rust prevalence and intensity from year to year are shown by dotted lines in Figure 10. From 1922 to 1923 the trend of apple rust, both in prevalence and in intensity, was upward, and the relative increase was nearly equal for the two aspects of the disease. From 1923 to 1924 both trends were downward, the intensity of the attack decreasing much more rapidly than prevalence. Between 1924 and 1926 no record is available; and the trends from 1924 to 1925 and

TABLE VIII
PREVALENCE AND INTENSITY OF APPLE RUST

Year	Prevalence	Intensity	Basis of data		
	Percentage of trees having rust infection	Percentage of leaf area infected by rust	Number of records	Number of trees represented by the records	Number of counties represented in the records
1922.....	26.29	1.57	16	3,503	14
1923.....	57.29	3.70	14	6,210	8
1924.....	38.77	0.25	29	23,056	23
1926.....	72.51	14.63	12	2,445	9
1927.....	81.22	0.06	23	6,998	9
1928.....	95.72	0.10	22	11,165	7
Total.....			116	53,377	70
Averages.....	61.96	3.38	19	8,896	11

from 1925 to 1926 cannot be indicated. Hence, the light line on the graph serves only to connect the actual data points.

In 1926, prevalence and intensity were both very high; and in the following year, 1927, we have the remarkable phenomenon of a still further increase in prevalence contrasted with a very rapid decline in intensity. In 1928 prevalence increased still further, and by referring to Table VIII, it may be seen that there was an accompanying increase in intensity, though it was too slight to be shown on the graph. It appears that throughout our period of observation, the trend of apple rust has been to increase rather steadily in prevalence; but the intensity of the attack has varied greatly from year to year and has shown a considerable degree of independence in its trends as compared with prevalence.

SUMMARY OF APPLE DISEASE DATA

The observations given in the preceding pages have dealt with the individual diseases, and no comparisons have been made between diseases, as regards either their prevalence or their intensities. It will be of some interest, therefore, to compare changes in prevalence from year to year, and changes in the intensity of various types of attack of all diseases, and to determine the total effects of all over a period of years as exemplified in the years covered by our survey.

Prevalence of Apple Diseases

In Table IX, the prevalence indexes for all apple diseases are brought together so that the prevalence of each disease each year may be compared with the prevalence of every other disease.

TABLE IX
SUMMARY OF PREVALENCE OF APPLE DISEASES

Disease	1922	1923	1924	1925	1926	1927	1928
Scab.....	93.00	74.85	63.98	98.58	16.32	93.77	93.32
Black-rot.....	65.64	55.54	82.65	91.41	91.57	100.00	100.00
Blotch.....	53.03	89.14	87.68	100.00	46.67	71.87	57.91
Fire-blight.....	42.64	72.85	65.41	59.85	58.89	21.04	81.01
Rust.....	26.29	57.29	38.77		72.51	81.22	95.72
Average incidence of disease per tree.....	2.81	3.50	3.38	3.50	2.86	3.68	4.27

As this table shows, in 1922 scab was the most prevalent disease and rust the least prevalent, with black-rot, blotch, and fire-blight intervening and ranking in prevalence in the order in which they are named. In 1923, blotch became the most prevalent disease, with scab second, and fire-blight, rust, and black-rot following in order. In 1924, blotch continued to maintain the lead in prevalence, but black-rot rose again to second place, while fire-blight, scab, and rust occupied the places of lesser importance, and in 1925 blotch again held the highest prevalence position, with scab in a very high second place, black-rot also very high, and fire-blight last. Without noticeably increasing its prevalence, black-rot occupied the first place in 1926, with rust second, fire-blight third, blotch and scab in fourth and fifth places; and in 1927 it still held the lead with a prevalence index of 100 per cent., while the order of prevalence for the other apple diseases was rearranged to give scab second place, rust third place, and blotch and fire-blight fourth and fifth respectively. In the final year, 1928, black-rot, with its prevalence index again at 100 per cent., continued to hold first place, with rust and scab second and third, and fire-blight and blotch in the fourth and fifth places.

If the annual prevalence indexes for these five epidemic diseases were added, each yearly total would be greater than 100. Although it is self-evident that the percentage of diseased apple trees can not be actually in excess of 100 per cent., these totals of the prevalence indexes would serve to express, for the purpose of comparison, the relative success these apple tree diseases attain annually. The total of the prevalence indexes for 1922 is 281, while for 1923 it is 350. As numerical averages, these figures indicate that in the first year the incidence of apple diseases, as is shown in Table IX, was 2.81 per tree and in the second year 3.5 per tree. Ranking the years included in our survey according to the incidence of diseases per tree, they stand in the order shown by Table X.

TABLE X
YEARS RANKED ACCORDING TO THE AVERAGE INCIDENCE OF
DISEASES PER APPLE TREE

Rank	Year	Incidence of diseases
1.....	1928	4.27
2.....	1927	3.68
3.....	1925	3.50
4.....	1923	3.50
5.....	1924	3.38
6.....	1926	2.86
7.....	1922	2.81

As was indicated in Table X, the average incidence of diseases per tree in any one year differs to a considerable extent from that in other years. This is due both to annual fluctuations in total incidence and to fluctuations from year to year by each disease. The prevalence trend of each disease throughout the survey period is shown graphically by the lines in the lower part of Figure 11, and these may be compared with the trend of average incidence per tree shown by the line in the upper portion of the same figure.

Outstanding in this diagram is the reduction in average incidence of diseases per tree in 1926. This is a reflection of the distinct drop, in the same year, of the prevalence of both scab and blotch. The rise in average incidence from 1922 to 1923 was the result of a rise in the prevalence of blotch, fire-blight, and rust, which was only partly counter-balanced by the decreased prevalence of scab and black-rot. In 1924 the prevalence of scab continued to decrease, and all other diseases except black-rot decreased more or less noticeably; and these conditions are reflected in the slight drop shown for 1924 in the average incidence curve at the top of Figure 11. In the following year, 1925, the prevalence of scab, blotch, and black-rot rose to very high points, while fire-blight fell off somewhat from its previous position. The absence of rust data undoubtedly influenced the situation also, but to what extent can not, of

course, be determined. The result of the movement of the known prevalence indexes was, nevertheless, to bring about a rise in the disease incidence curve to approximately the height of 1923.

In 1926, three diseases fell off in prevalence, scab very sharply, blotch quite sharply also, and fire-blight only slightly, while of the other two diseases, black-rot increased somewhat in prevalence and rust rose to the highest point recorded up to that time. The net result of these changes was to drop the disease incidence curve to a point only slightly higher than it occupied in 1922.

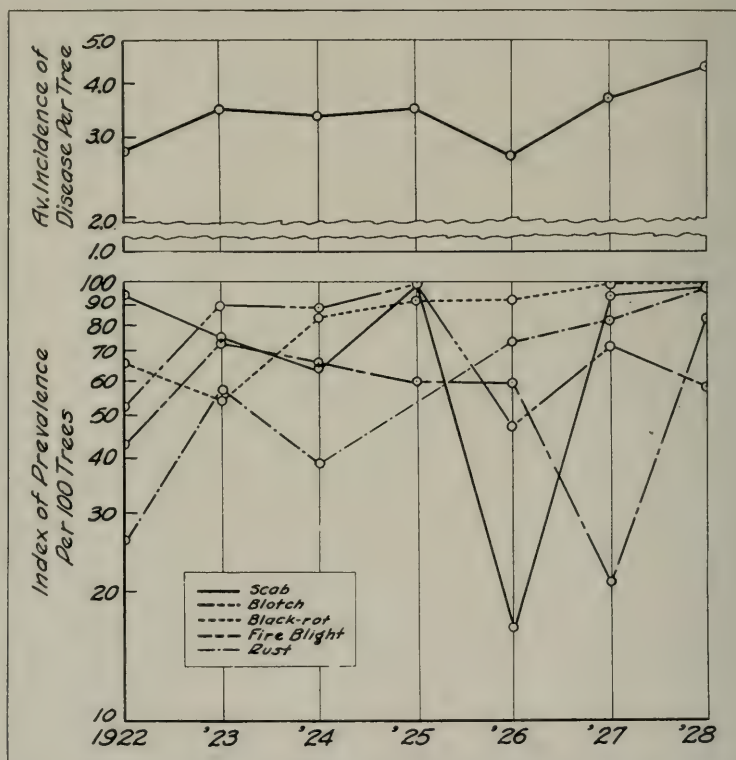


FIG. 11. COMPARISON OF THE PREVALENCE TRENDS OF APPLE DISEASES AND OF THE AVERAGE INCIDENCE OF DISEASE PER TREE. SEE TEXT FOR DISCUSSION

The general retrogression of disease prevalence in 1926 was compensated during the 1927 season by a rise in prevalence of all diseases except fire-blight, which fell to its lowest point in our series of records, and the result was to raise the disease incidence curve to the highest point recorded up to that time.

This general increase was continued into 1928. Fire-blight rose very sharply to a high degree of prevalence, black-rot, rust, and scab maintained or increased their former high indexes, and blotch alone decreased, with the net result that the average incidence of diseases per tree rose, as the upper curve shows, to the high point of 4.31.

AVERAGE ANNUAL PREVALENCE

Our records, covering as they do the changes in disease prevalence exemplified by seven growing seasons, during which each disease encountered at one time or another conditions that were favorable or unfavorable to its propagation, may be held to represent to a rather exact degree the average prevalence of each of the epidemic diseases which the orchardist may expect to have to meet over a period of years under Illinois conditions. This expectation, which may be expressed as the average annual prevalence computed for each disease from the indexes given in Table IX, is shown graphically in Figure 12. Fire-blight may be expected to be least prevalent, with rust, blotch, scab, and black-rot increasingly prevalent in the order named. And the individual tree, as indicated by the uppermost block in Figure 12, may be expected to encounter an average incidence of 3.4 diseases per year.

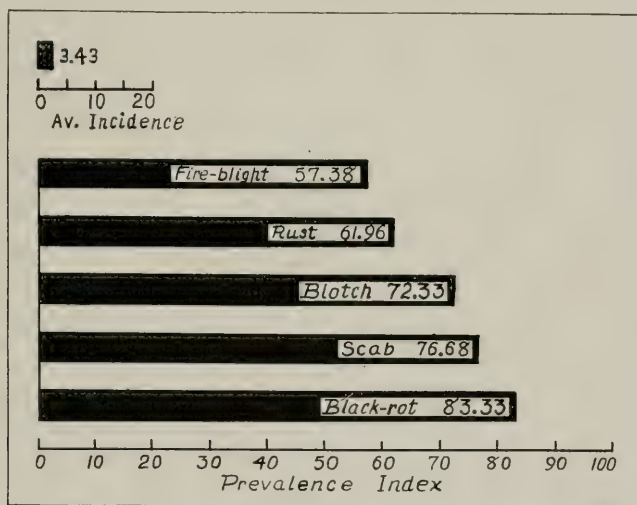


FIG. 12. AVERAGE PREVALENCE OF APPLE DISEASES

The blocks illustrating the prevalence of each disease show, by their length, the average number in every 100 trees attacked by each disease, and the small block representing average incidence, indicates the average number of diseases present on each tree.

Intensity of Apple Diseases

In the discussions given to the individual apple diseases on previous pages, the measurement of the intensity of disease has been concerned with three distinct phases: the prevalence of the disease on fruit, the quantity of twigs or young growth attacked, and the amount of leaf area occupied by lesions. It will be of some interest to consider each of these phases as they are affected by all five of the epidemic diseases and to see whether or not there is any relation between these types of attack and prevalence.

FRUIT INTENSITY

Data are at hand to show the intensity of fruit attack in the case of only three diseases, scab, blotch, and black-rot. These are shown in Table XI. In the first year, 1922, blotch attack was the most intense, occurring on 41.36 per cent. of the fruit in the plantation found to be diseased and scab was only slightly less intense, with an index of 37.45 per cent.

Throughout the entire period black-rot occupied a very minor place, only once, in 1924, attacking in excess of 1 per cent. of the fruit. The place of first importance as a fruit disease was held 4 times by blotch (1922, 1925, 1926, and 1927), while scab was most important in the three seasons 1923, 1924, and 1928.

The totals given for the annual indexes show the total incidence of disease on the fruit each year. As these figures indicate, 1922 with its total index of 79.61 is outstanding for the amount of fruit attacked. Next in order stands 1923 with an index of 69.83. The remaining years, 1924 to 1928 inclusive, have total indexes of a much lower grade; but 1925 with its very low index of 9.09 is very certainly the year of least fruit injury.

TABLE XI
SUMMARY OF INTENSITY OF APPLE DISEASES ON FRUIT

Disease	1922	1923	1924	1925	1926	1927	1928
Blotch.....	41.36	32.15	3.89	9.09	12.48	18.34	9.37
Scab.....	37.45	37.23	24.52	trace	.01	6.36	10.36
Black-rot.....	.80	.45	1.05	trace	.17	.01	.01
Total.....	79.61	69.83	29.46	9.09	12.66	24.71	19.74

The trends of the individual fruit disease indexes and of the total index are compared in Figure 13. In this case, the fact that the trend of the total intensity index follows directly the large changes from year to year in the blotch and scab indexes indicates the importance of these diseases. The practical maintenance of the scab index of 1922 in 1923 was not, however, sufficient to maintain the height of the total index in the fact of the slight fall in the blotch index; but it does not appear that the sharp fall, in 1923, in the already small black-rot index contributed very largely to the downward movement of the total index line. A continued downward movement of the total index line in 1924 was due to decided drops in both the blotch and scab indexes of fruit intensity and in 1925 to the very sudden fall in the scab index since the value of the total index that year was exactly that of the blotch index. A slight rise in the indexes of both blotch and black-rot in 1926 started the total fruit-disease index line on an upward trend, which was extended through 1927 by the continued rise of the blotch index and the resurgence of the scab index. This height was not maintained in 1928.

however, even though the scab index continued to rise, for the blotch index fell off so sharply as to cause a distinct lowering in the total amount of diseased fruit.

The outstanding fact illustrated in Figure 13 is that in spite of the annual fluctuations of individual disease indexes the total fruit-disease index moved steadily from the high point of 1922 downward to the low point of 1925, after which it began again to rise; and though its upward progress has not been uniform, the upward trend is evident through 1928.

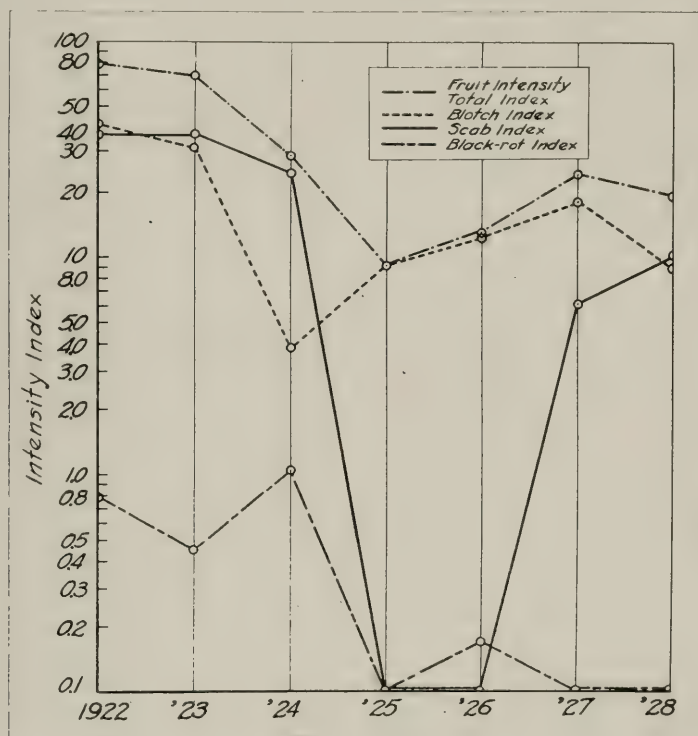


FIG. 13. COMPARISON OF THE TRENDS OF THE TOTAL ANNUAL FRUIT INTENSITY INDEXES WITH THOSE OF THE ANNUAL FRUIT INTENSITY INDEXES OF EACH APPLE DISEASE. SEE TEXT FOR DISCUSSION.

INTENSITY OF ATTACK ON TWIGS

Data have been taken, as shown in the special discussion of diseases, for twig disease produced by blotch, black-rot, and fire-blight. The indexes of intensity derived from these data are brought together in Table XII, where they are shown comparatively by years; and the total effect of these diseases is estimated for each year by summing the intensity indexes.

With the single exception of 1924, blotch was more intense in its twig attack than either fire-blight or black-rot; and black-rot was the least intense in all years. Fire-blight occupied the middle place in all years except 1924, when it exceeded blotch by the small amount of 2.28 per cent. The year 1923 is outstanding for its exceptionally heavy manifestation of twig disease; and it is also worthy of special notice that 1925, a year when fruit attack was at a minimum and leaf disease at a very low ebb, has the second place for intensity of twig disease.

The trends of the individual diseases, as manifested in terms of diseased twigs, is shown in Figure 14 in comparison with the total percentage of diseased twigs. Starting at the moderate total of 13.45 in 1922, the total intensity of twig disease rose very sharply in 1923 to the high total of 91.35, following very closely in this the upward trends of blotch and fire-blight, which were opposed by a sharp fall in the slight intensity of black-rot. From this high point, the total intensity fell in 1924 to 21.36, chiefly as a result of the sharp decline in the blotch intensity index; but the rate of fall of the total intensity line was lessened by an appreciable rise in the fire-blight index and a

TABLE XII
SUMMARY OF TWIG INTENSITY OF APPLE DISEASES

Diseases	1922	1923	1924	1925	1926	1927	1928
Blotch.....	10.49	81.29	8.41	54.54	.....	7.59	3.59
Fire-blight.....	1.86	9.61	10.69	4.76	4.49	0.09	3.05
Black-rot.....	1.10	.45	2.26	trace	.004	0.0	trace
Total.....	13.45	91.35	21.36	59.30	4.494	7.68	6.64

sharp upward movement in the black-rot trend. In 1925, the total intensity line rose again, reaching 59.30, the rise being due entirely, as may be seen in Figure 14, to the sharp climb made by the blotch index, and its failure to reach a point nearly equal to that attained in 1923 was due to a distinct falling off in the indexes of both fire-blight and black-rot.

The downward trend shown for the total index line between 1925 and 1926 may be much too steep. In the latter year, circumstances beyond our control prevented the accumulation of adequate data for blotch on twigs; but it is probable, in view of the general decline of other types of infective blotch material in 1925, that the twig intensity of 1926 was at least as low as in 1924. The upward trend of the total index line from 1926 to 1927 is, for the same reason, probably slightly exaggerated. Its real trend may actually have been downward.

Between 1927 and 1928 the trend of the total index is shown to have sloped downward. This results, as may readily be seen, from a fall in the blotch index, which was only partly balanced by the rapid rise of the insignificant fire-blight index.

It is of interest to note that, of the three diseases causing twig injury, fire-blight appears to fluctuate less from year to year than the other two. The changes exhibited by both blotch and black-rot, as exemplified in the years 1922-1925, are rather extensive and cause their lines on the graph to move sharply up and down. It is striking also that in the four comparisons which the data for year-to-year trends make possible, the indexes for these two diseases travel consistently in opposite directions. In the four possible comparisons between blotch and fire-blight, there are three instances of opposed trends, and one of similar

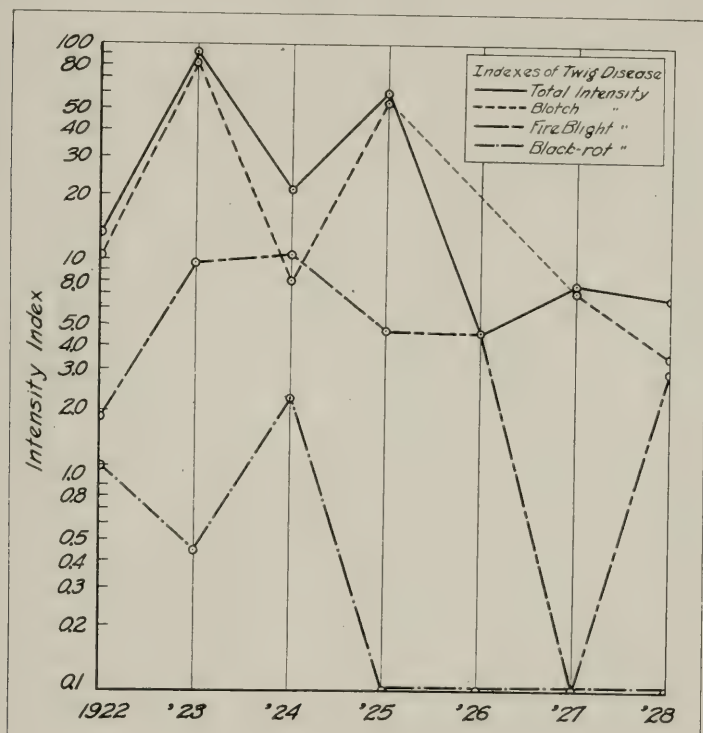


FIG. 14. COMPARISON OF THE TRENDS OF THE TOTAL ANNUAL TWIG INTENSITY INDEXES WITH THOSE OF THE ANNUAL TWIG INDEXES OF EACH APPLE DISEASE. SEE TEXT FOR DISCUSSION.

trend, while the six comparisons of trend which can be made between fire-blight and black-rot furnish three instances in which the trends are opposite and three in which they are similar.

LEAF INTENSITY

The injury done to apple trees by destruction of the leaves may result from any one or all five of the epidemic diseases. Fire-blight, however, causes injury to the leaves mainly by killing the young twigs upon which the leaves are borne; and in this sense it is not, at least

in Illinois, an epidemic leaf disease. Scab, blotch, black-rot, and rust, however, have a distinctive type of leaf attack, which results in the killing or injuring of a particular portion of a leaf while the remainder of the leaf maintains a healthy, functioning condition. The extent of the leaf injury which these diseases cause by direct attack has been shown for each disease in the individual discussions, where an index was given representing the average leaf area occupied by lesions each year. These indexes are gathered together in Table XIII for comparison, and their annual totals, given at the bottom of the table, furnish within the limits under which they were gathered, a statement of their total effect in terms of the percentage of leaf area occupied or destroyed.

TABLE XIII
SUMMARY OF LEAF INTENSITY OF APPLE DISEASES

Diseases	1922	1923	1924	1925	1926	1927	1928
Scab.....	8.13	14.45	6.65	0.22	0.22	1.95	2.84
Blotch.....	2.56	3.89	trace	1.93	.01	trace	trace
Rust.....	1.57	3.70	.25		14.63	.06	.10
Black-rot.....	.36	.18	.52	1.09	.16	.15	.05
Total.....	12.62	22.22	7.42	3.24	15.02	2.16	2.99

Excepting in 1925 and 1926, scab was the most destructive of the diseases attacking leaves, the area occupied by its lesions amounting to two-thirds of the total occupied leaf area in 1922 and 1923, more than six-sevenths in 1924, and nearly the entire amount in 1927 and 1928. Blotch was the chief cause of leaf damage only in 1925, though in 1922 and 1923 its importance was greater than either rust or black-rot. In general, rust was of slight significance, its ordinary maximum of 3.70, attained in 1923, being of no great importance; but the extraordinarily large rust index of 1926, 14.63, which compares directly with the scab index of 1923, shows that under certain conditions the rust of apples can become a serious menace to apple foliage. Black-rot was in all years a disease of very minor significance, only in 1925 becoming serious enough to account for a reduction in leaf area exceeding one per cent.

When taken together, the leaf intensity indexes indicate that of the 7 years shown by our data, 1923 was outstanding as the year of severest leaf disease, with 1927 ranking as the year of least severity. There is, as might be expected, a very considerable difference between the individual years, as regards both the individual diseases and their total effects.

The year-to-year trend of each disease, and of the annual totals of their indexes, is shown graphically in Figure 15. Here it appears that the total index line, as well as those for scab, blotch, and rust, follows the same trends—a rise from 1922 to 1923 and a fall from 1923 to 1924—during the first three years, while black rot moves in an opposite manner. With the arrival of 1925, however, this agreement in trend is

broken, the downward trend of the total index line resulting almost entirely from the steep fall of the scab index, since blotch and rust unite in the opposite trend. In 1926, again, rust alone is responsible for the upward turn in the total index line, the trend of all other diseases being downward, except scab which moved neither up nor down.

The rapid fall in 1927 of the rust index, coupled with only very slight changes in all other indexes except that of scab, brought the total index trend down practically to the level of the increasing scab index;

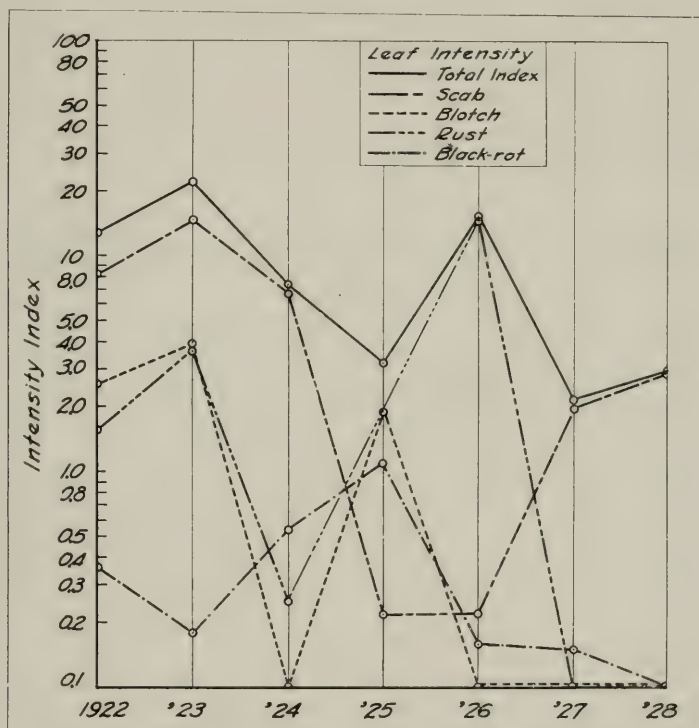


FIG. 15. COMPARISON OF THE TRENDS OF THE TOTAL ANNUAL LEAF INTENSITY INDEXES WITH THOSE OF THE ANNUAL LEAF INTENSITY INDEXES OF EACH APPLE DISEASE. SEE TEXT FOR DISCUSSION.

and in 1928 the continued rise of the scab index, though unaccompanied by marked changes in the insignificantly low indexes of the other leaf diseases, started the total index of leaf disease again in an upward direction.

The general trend of leaf disease was upward from 1922 to 1923, but downward from 1923 through 1925, while in 1926 the constant level of scab and the high rust index predict the beginning of a later general rise which becomes somewhat more apparent in 1927 and 1928.

Total Effect of Apple Diseases

The diseases of apple trees combine, in the intensity of their various types of attack, to injure the trees permanently and to interfere with the annual production of crops both by the permanent injury they do and by the season's infection on the fruit and the damage done to leaves, upon which the tree depends for a supply of material with which to form its fruit.

The effects of these diseases, as we have observed them in Illinois, are shown graphically in Figure 16. The tabulation presented as part of the graph shows the totals of the annual indexes for each type of attack, and the cross-hatched blocks of the diagram present a visual comparison of the yearly sums. Thus, it is evident that 1923 held first place as a year of destructive disease, while 1926 was the year of least

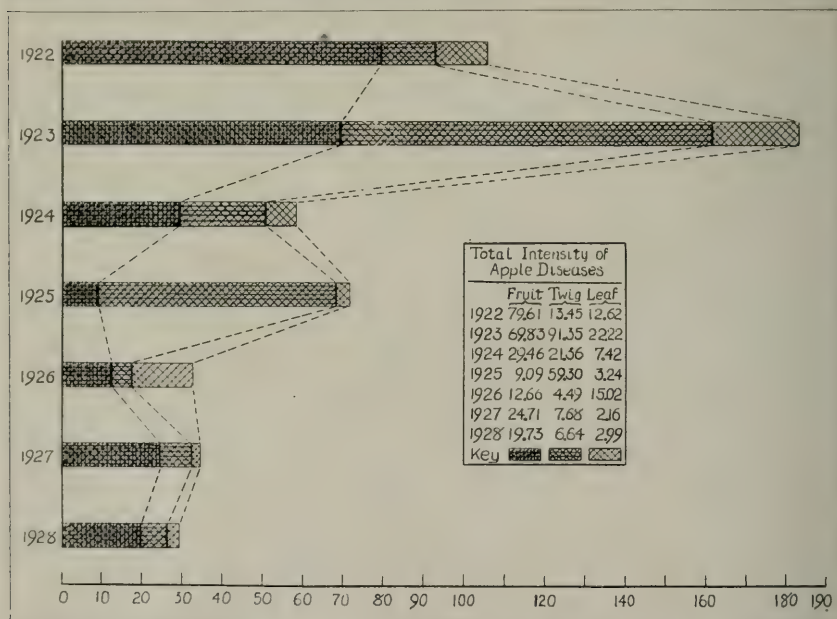


FIG. 16. COMPARISON OF THE TOTAL INTENSITY OF THE ANNUAL EPIDEMICS OF APPLE DISEASES

The total indexes of fruit, twig and leaf intensity shown in the table are combined graphically in the block diagrams to show the relative intensity of all epidemics in each of the years covered by the survey. The tendency of fruit, twig, and leaf disease to fluctuate independently from one year to another is also shown.

destructive disease. It appears also that the two first years, 1922 and 1923, were characterized by a very great severity in disease, but that in 1924, and in the succeeding years, the intensity of disease attack decreased to moderate or small amounts.

The graph also illustrates the proportional effects of each type of attack in each year and shows how an increase in the intensity of one type of attack, even when accompanied by decreases in the intensity of

the other types, may serve to heighten the total effect of disease. Thus in 1922, the intensity of attack on fruit constitutes a little over 75 per cent. of the entire manifestation of intensity, while the remaining 25 per cent. is divided quite evenly between twig and leaf intensities. In the following year, however, the intensity of fruit attack was actually less by one-eighth and the leaf intensity nearly double that of 1922, yet the length of the column is greater by nearly three-fourths, because of the excessive increase in twig disease, which amounts to nearly half the total manifestation for the year. The very great decrease in the total manifest disease in 1924 is due to marked shrinkage in all types of attack, the proportional reduction being greatest in twig disease, which was less than one-fourth as intense as in 1923, while the reduction in both leaf and fruit intensity was approximately two-thirds.

In 1925, a year known among commercial growers for the very small amount of apple tree disease, there appears actually to have been a total manifestation of disease large enough to rank third among the years covered by our observations; but it will be seen that this is due entirely to an increase in twig disease to nearly three times its amount in the preceding year, and that the intensities of leaf and fruit attack, the latter especially noticed by the orchardist, decreased to approximately one-half and one-third, respectively, of their preceding amounts. The still further decrease in total manifestation of disease evident in 1926 did not materially impress the grower, for the reason that the decrease resulted very largely from the heavy falling off of twig disease from an index of 59.30 in the previous year to 4.49 in that year, while the fruit and leaf attacks, both of which he was more apt to observe, showed definite increases over the previous year and thereby gave, falsely, the impression of an increased amount of disease.

In 1927, there was only a very slight increase in the total manifestation of disease, but the change from 1926 consisted in doubling of the fruit intensity index, thus characterizing the season's disease attack as being commercially destructive to almost the same extent as that of 1924, with an increase in twig disease to but twice its former small amount and a decrease in leaf intensity to one-seventh. In 1928 there was not much change in the amounts of leaf and twig disease, but the total manifestation of disease appeared somewhat less through a decrease in the fruit infection to about four-fifths of the amount present in 1927.

In general, Figure 16 serves to illustrate and emphasize, from the point of view of total disease manifestation, the tendency of each type of attack to fluctuate from year to year entirely independently of other types of attack. It is also evident that commercial phases of disease, or those readily observable by growers, are apt by themselves to lead to erroneous estimates of the total effects of disease attack. It is only by compiling data on all phases that the real characteristics of any year with respect to disease severity can be determined.

It is of interest, also, to see what our data indicate in the way of a general condition which the orchardist must face in the intensity of disease attack through a period of years. As was illustrated in Figure 16, the total intensity of disease and also the intensity of each type of attack may vary widely from one year to another. The average condi-

tion derived from these variations may, however, be indicative of the relative importance of each disease and, in general, also of the relative importance of each type of disease manifestation over a period of years.

Figure 17 compares the average annual intensity in fruit, twig, and leaf attack of the diseases listed in tables on previous pages, as shown by our data. The tabulation which appears as part of the diagram gives the average annual intensities of each type of attack as exemplified by our data for each disease and also the total average intensity of each type of attack brought about by all diseases. The figures in the table are shown graphically by the series of blocks.

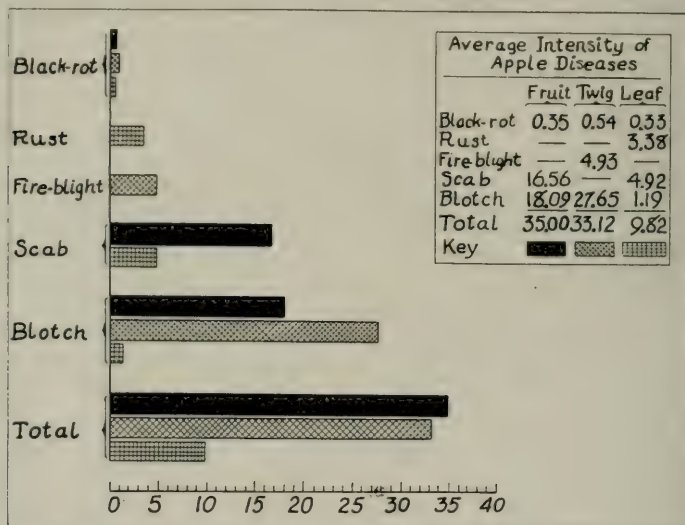


FIG. 17. COMPARISON OF THE EPIDEMIC APPLE DISEASES WITH RESPECT TO THEIR AVERAGE INTENSITIES

The tabulation gives the average annual fruit, twig, and leaf intensity indexes for each disease, and these indexes are shown graphically by the block diagrams.

From these, it is readily seen that black-rot, previously determined to be the most prevalent of apple diseases, is over a period of years actually the least serious disease. Rust, with its single measured manifestation of leaf disease, appears to be of minor importance also, though a certain small additional fruit attack which we have never measured lends it a commercial importance approaching that of black-rot. Fire-blight, which we have measured only in terms of twig disease, appears third in the ascending order of importance, but as a commercial factor it probably ranks higher than the graph seems to indicate, since necessarily a considerable reduction in yield occurs as a result of the acute annual attack on blossoms and fruit spurs.

Scab, with its average annual fruit infection index of 16.56, is second only to blotch as a limiting factor in the commercial production of apples, but its wider geographical range in Illinois would seem to

justify giving it the first rank in importance for the State as a whole. In its destructive effect upon the trees, however, it is plainly less important than blotch, as its leaf infection index of 4.92, though more than four times as great as that of blotch, is more than compensated for by the high intensity of blotch twig attack. Hence, it appears that of all the epidemic diseases, blotch holds first place in importance, at least in the commercial regions of the state.

The average total intensity of the epidemic diseases, taken over a period of years, is shown also in Figure 17. Of the three manifestations of intensity, the fruit attack is the largest, though it exceeds the twig attack by only a small amount. Leaf disease, often the most conspicuous phase, appears on the whole to be the least significant, though the more particular pains taken to measure it may have reduced its expression in a somewhat misleading way. It seems, however, from the data at hand, that over a period of years, a fruit grower may expect fruit disease and twig disease to dominate leaf attack, the first averaging annually about 35 per cent. of the crop, the second, year after year involving an average of about 33 per cent. of the new tree growth, and the leaf disease amounting on an average to slightly less than 10 per cent. of the total leaf area.

In these totals, black rot will play but a small part; rust will contribute chiefly to leaf-injury; fire-blight will be important in twig injury; scab will seriously effect both the fruit and leaves; and blotch will be the most serious of the diseases on fruit and twigs, but of minor importance on leaves.

PEAR DISEASES

In Illinois, pears suffer as a rule from the attack of only one serious disease, namely blight. There are, of course, other diseases, particularly two that appear as leaf spots; but the damage they do is very slight indeed, and it has been our experience that they occur but rarely in destructive amounts and then only in very restricted areas. The "leaf blight" due to the fungus *Fabraea maculata* (Lev.) Atk. is perhaps the more serious of these, as it also appears at times upon the fruit; and the more common *Septoria* leaf-spot (caused by *Mycosphaerella sentina* (Fr.) Schr.) does very little injury. Consequently, our data on pear diseases is concerned only with pear blight.

PEAR BLIGHT

Caused by *Bacillus amylovorus* (Burr.) Trev.

The commercial production of pears in Illinois is very largely conditioned by the annual epidemics of pear blight. The disease, caused by the same bacterium as fire-blight on apples, manifests itself as blossom and twig blight, as spur blight, and as a very severe canker of the limbs and trunk. Its destructiveness, which may be seen to be very great, has been observed by pear growers to vary to such an extent from year to year that they commonly designate years as of mild or of heavy blight.

In measuring the annual epidemics of pear blight in Illinois, we have taken into account only the phase of its attack known as twig-blight, including in this general type, however, the spur-blight phase and leaving out for the present any separate consideration of blossom-blight or cankers. Our data consist of percentage statements, obtained by representative counts, of the prevalence of blight infection among trees and of the intensity of the attack, expressed as the percentage of blighted twigs and fruit spurs.

Data on Pear Blight

Because of the scattered distribution of pear plantations, as well as because of the relatively small number of pear trees grown in the State, we have not been able, in the course of our survey, to secure as abundant records for pear diseases as for the diseases of the more important fruits.

TABLE XIV
PREVALENCE AND INTENSITY OF PEAR BLIGHT

Year	Prevalence	Intensity	Basis of data		
	Percentage of pear trees infected by blight	Percentage of twigs infected by blight	Number of records	Number of trees represented by the records	Number of counties represented in the records
1922.....	20.45	1.59	88	17,064	38
1923.....	96.28	18.44	38	8,085	23
1924.....	71.64	20.53	70	8,996	41
1925.....	45.33	5.61	13	4,059	11
1926.....	81.19	14.21	21	4,806	14
1927.....	30.72	2.31	5	2,109	4
1928.....	5.53	0.16	5	2,231	2
Total.....			240	47,350	133
Averages.....	50.16	8.98	34	6,764	19

As shown in Table XIV, however, there have been 240 observations made of pear-blight in the course of the survey, or an average of 34 per year, and the average number of trees represented in the yearly records is 6,764. There has also been an average of 19 counties represented annually in the records.

In 1922 observations on pear blight were made in 88 plantations containing a total of 17,064 trees and distributed among 38 counties. The prevalence of the disease, as determined from these observations, is shown in Table XIV as 20.45 per cent., and the same observations give the disease a twig-blight intensity of 1.59 per cent. In 1923, however, the records obtained from 38 plantations show a very great increase in

prevalence, the index being 96.28, and an even greater relative increase in twig-blight intensity, which has an index of 18.44.

For 1924, the prevalence of pear blight was determined to be 71.64 per cent. and the twig-blight intensity 20.53 per cent. This shows a decided fall in prevalence from the previous year but a slight increase in intensity.

The epidemic of 1925, as shown by our 13 observations, was milder than those of either 1923 or 1924, but more severe than that of 1922. Its prevalence was 45.33 per cent. and its intensity 5.61 per cent. This

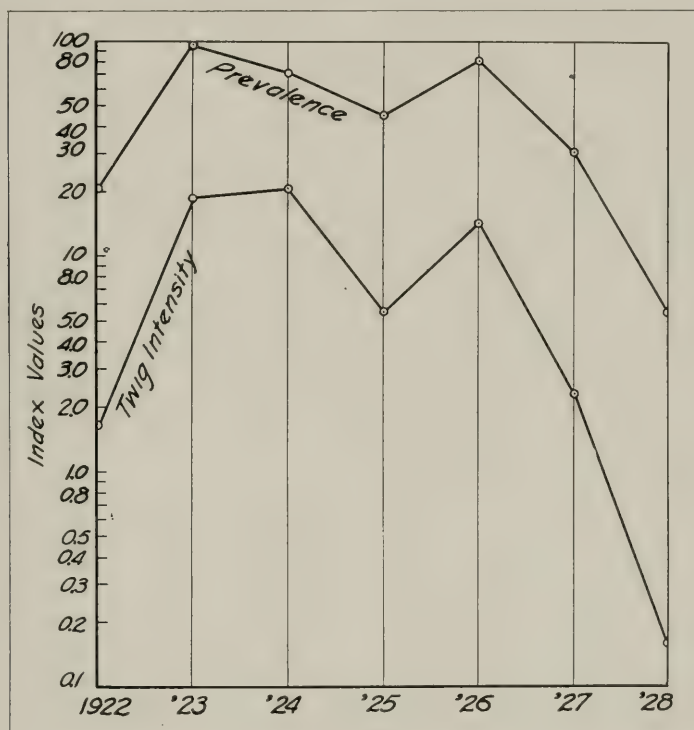


FIG. 18. TRENDS OF PREVALENCE AND INTENSITY OF PEAR-BLIGHT. SEE TEXT FOR DISCUSSION

tendency to decrease was not maintained in 1926, however, for in that year 21 records representing 4,806 trees gave the high prevalence index of 81.19 and a twig intensity index of 14.21.

In 1927 the epidemic was again mild, the prevalence of the disease being only 30.72 per cent. and its twig intensity 2.31 per cent. This very sharp reduction in the severity of blight was continued into 1928, when the prevalence index reached the very low point of 5.53 and the twig intensity index fell to 0.16.

The year-to-year trends of the prevalence and twig intensity phases of the pear blight epidemics are shown graphically in Figure 18. In

general, the movement of both phases follows the same trend, though between 1923 and 1924, when prevalence moved downward and twig intensity upward, the opposite appears to have been true. The upward or downward trend is usually more pronounced in the intensity phase than in the prevalence phase.

The graph illustrates, also, the great prevalence and destructiveness of the blight epidemics in the years 1923, 1924, 1925, and 1926, which are in marked contrast with the rather mild destructiveness of 1922, 1927, and 1928.

Through the period covered by our data, as may be seen in Table XIV, pear-blight has been present on an average of 50.16 per cent. of the trees we have examined, and 8.98 per cent. of all twigs on all these trees have been attacked by the disease.

PEACH DISEASES

Though they have always been important limiting factors in production, peach diseases have recently taken on a still greater economic significance in Illinois because of a great increase within the last 10 years in the number of commercial peach plantations set out within the State. The Bureau of Agricultural Economics of the U. S. Department of Agriculture made a survey of the peach trees in Illinois during the fall and winter of 1925-1926, the results of which, made available in May, 1926, indicate that there were in the State at that time 2,293 peach orchards of 100 or more trees. And it was estimated that there were in these orchards 1,923,012 peach trees, of which a little over 320,000—approximately one-sixth of the entire number—were less than two years old and 772,000, or 40 per cent., were two and three years old. Since the completion of this survey, these trees have come into bearing and more orchards have been planted, and both together are yielding crops estimated at 1,122,000 bushels in 1927 and 1,638,000 bushels in 1928. The farm value of the 1927 crop was estimated to be \$2,300,000 and that of the 1928 crop \$2,293,000.

All the important or destructive diseases that occur on peaches in Illinois are epidemic in their behavior, that is, they attack one or more parts of the tree anew each year; and the success of each year's attack is determined in large measure by the prevailing weather. In the measurement of these annual epidemics, the methods that have been used are the same as those described for apple diseases.

PEACH BROWN-ROT

Caused by *Sclerotinia cinerea* (Bon.) Schroeter

The attack of the brown-rot disease on peach trees is by no means limited to the fruit, from which it takes its name, but is destructive also to blossoms and twigs. In measuring its annual epidemics, however, we have had to limit the collection of data to the fruit-rot phase of the disease, except for the years 1926 and after, when data were taken on twig-blight also. At present, however, we intend to present the accumulated data on prevalence and fruit-rot only.

Data on Brown-rot

During the period of our survey, we have observed brown-rot in 135 peach plantations, an average of 19 per year. The average number of trees furnishing the annual records is 15,973 and the average number of counties represented yearly is 8. As may be seen in Table XV, the average annual prevalence of brown-rot indicated by these records is 42.67 per cent., while the average intensity of its attack on fruit is 5.73 per cent.

TABLE XV
PREVALENCE AND INTENSITY OF PEACH BROWN-ROT

Year	Prevalence	Intensity	Basis of data		
	Percentage of peach trees infected by brown-rot	Percentage of fruit infected by brown-rot	Number of records	Number of trees represented by the records	Number of counties represented in the records
1922.....	88.24	2.29	35	1,796	17
1923.....	25.22	0.53	10	4,310	9
1924.....	97.41	27.36	7	7,705	7
1925.....	trace	trace			
1926.....	9.26	trace	19	5,041	13
1927.....	55.88	8.47	16	12,400	5
1928.....	22.68	1.52	48	80,565	10
Total.....			135	111,817	61
Averages.....	42.67	5.73	19	15,973	8

The annual variation in the prevalence and intensity of brown-rot is also shown in Table XV. In 1922, when 35 orchards were examined and data secured from a total of 1,796 trees distributed among 17 counties, the brown-rot prevalence index stood at 88.24 per cent., while the intensity of the fruit attack had an index of 2.29 per cent. In the next year, 1923, 10 records taken in 9 counties and representing the diseased condition of 4,310 peach trees showed a drop in prevalence to 25.22 per cent. and a corresponding drop in the intensity of the fruit attack to 0.53 per cent. But with 1924 there was a very sharp increase in both prevalence and intensity, the former rising to 97.41 per cent. and the latter to 27.36 per cent., both of these being the highest indexes recorded for brown-rot. No satisfactory data were obtained in 1925; but our general observations, coupled with those of peach growers and horticultural experts, establish the practical absence of the disease that year. The indexes for 1926, 9.26 per cent. for prevalence and a trace only for fruit intensity, indicate both the severe effect of the previous very unfavorable year upon the disease and the fact that the disease was again beginning to attain importance. In 1927 the prevalence index

rose to 55.88 per cent. and that for fruit intensity to 8.47 per cent., marking the epidemic of that year as second in intensity and third in prevalence among the years covered by the survey. With the arrival of 1928, however, brown-rot once more encountered unfavorable conditions and dropped in prevalence to 22.68 per cent. and in intensity to 1.52 per cent.

The trend of these annual brown-rot epidemics is shown graphically in Figure 19. It may be seen that with the exception of the change from 1925 to 1926, where the intensity of the fruit attack appears to have lagged behind the rising prevalence, the trends of both the prevalence and the intensity indexes follow the same courses throughout.

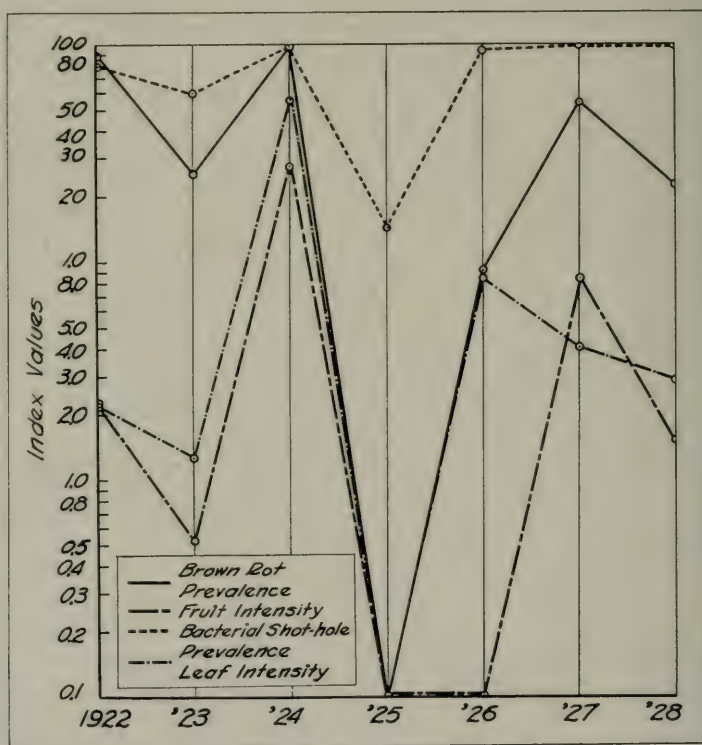


FIG. 19. TRENDS OF THE PREVALENCE AND INTENSITY OF THE BROWN-ROT AND BACTERIAL SHOT-HOLE DISEASES OF PEACH

The trend lines for both diseases show sharp changes from year to year, indicating their sensitivity to weather change. The year 1925 was marked by a sudden drop in the prevalence and intensity of both diseases, from which the bacterial shot-hole recovered in 1926. Brown-rot, however, though recovering its prevalence within a year, exhibits a lag of a year in recovering its former intensity.

The sharp movements both upward and downward of the prevalence and intensity lines indicate also that the disease is very greatly influenced by annual fluctuations in weather.

BACTERIAL SHOT-HOLE

Caused by *Pseudomonas Pruni* E. F. Smith

This disease, named from the shot-hole effect which its spots produce on peach leaves, also attacks the fruit and twigs. Of these three modes of manifestation, leaf attacks and fruit attacks are the most serious. Our data, however, will be presented to show only the prevalence of the disease and the intensity of its leaf attack.

In order to determine the annual intensity of shot-hole on peach leaves, the scale shown in Figure 20 has been devised. It is used in the same manner as the other leaf-spot scales which we have already described in connection with apple scab and other diseases. It should be emphasized especially that in this case as in all others the purpose of the scale is to measure the intensity of the disease attack in terms of



FIG. 20. SCALE FOR MEASURING THE INTENSITY OF ATTACK OF BACTERIAL SHOT-HOLE ON PEACH LEAVES

diseased leaf area and that it does not take into account the effect of the disease, which is to produce a distressingly high percentage of defoliation whenever the trees it attacks are growing in poor soil or when warm, moist atmospheric conditions prevail.

Data on Shot-hole

A total of 259 records have been secured for the bacterial shot-hole of peach during the course of our survey. As summarized in Table XVI, from an annual average of 37 records of the disease on 39,221 trees distributed among 17 counties, they indicate that shot-hole prevalence has

had the high average annual index of 77.11 per cent. and that the intensity of its attack on leaves has resulted, as an average, in occupation by lesions of 10.33 per cent. of the leaf area of all trees observed.

Table XVI also shows the variation, as indexes of prevalence and intensity, of the annual epidemics. Data taken in 1922 from 90 plantations containing 12,921 trees indicate a prevalence for that year of 79.62 per cent. and a corresponding leaf intensity of 2.21 per cent. In 1923, according to records taken in 21 plantations containing a total of over 76,000 trees, the prevalence of shot-hole dropped to 59.59 per cent. and its leaf intensity fell to 1.27 per cent. The following year, 1924, the data contained in 40 records representing 44,640 trees show a considerable increase in prevalence, the index rising to 95.52 per cent. and an even sharper rise in leaf intensity, the index for which stood at the very high level of 53.53 per cent.

TABLE XVI
PREVALENCE AND INTENSITY OF PEACH SHOT-HOLE

Year	Prevalence	Intensity	Basis of data		
	Percentage of peach trees infected by shot-hole	Percentage of leaf area occupied by shot-hole	Number of records	Number of trees represented by the records	Number of counties represented in the records
1922.....	79.62	2.21	90	12,921	42
1923.....	59.59	1.27	21	76,303	11
1924.....	95.52	53.53	40	44,640	27
1925.....	14.54	0.01	8	15,880	8
1926.....	93.98	8.41	28	23,530	13
1927.....	99.09	4.07	27	28,773	9
1928.....	97.47	2.87	45	72,505	10
Total.....			259	274,552	120
Averages.....	77.11	10.33	37	39,221	17

In sharp contrast with the high prevalence and intensity of 1924 is the condition shown by the 8 records of 1925, which represented 15,880 trees. The prevalence index fell to 14.54 per cent. and the leaf index to 0.01 per cent. these values being the lowest recorded by us in the seven years covered by our data. The apparently very adverse conditions of 1925 seemingly did not have a very prolonged effect on shot-hole, for in 1926, as our 28 records show, its prevalence rose to 93.98 per cent. among a total of 23,530 trees and the leaf intensity index rose to the relatively high point of 8.41 per cent. This rise was carried into 1927, when the data furnished by our 27 records indicated a rise in prevalence to 99.09 per cent. though at the same time the intensity of the leaf attack fell to 4.07 per cent. somewhat less than half its former value. In 1928, with 45 records furnishing data on the state of the disease as it pre-

ailed among 72,505 trees, prevalence was shown to have fallen slightly to 97.47 per cent. and leaf intensity somewhat more sharply to 2.87 per cent.

The trends from year to year of the shot-hole epidemics, as exhibited by their prevalence and leaf intensity indexes, are shown in Figure 19. With the exception of the change from 1926 to 1927, the trends of prevalence and intensity follow the same course; but it is evident that the changes in intensity are much sharper than those in prevalence. Following the very unfavorable year of 1925; both trends rise sharply and there is no apparent tendency for one to lag behind the other, as appeared to be the case with brown-rot. However, the changes from one year to another are rather sharp, as is observable also for brown-rot, and indicate that the disease is remarkably sensitive to annual changes in weather.

PEACH LEAF-CURL

Caused by *Exoascus deformans* (Berk.) Fuckel.

Leaf-curl is a common and often destructive disease in every peach region in the world and it is, naturally, prevalent throughout Illinois. It attacks the tree in a number of ways, causing a severe type of twig blight, attacking the blossoms and fruit and causing them to fall from the tree, and producing especially a leaf disease, which is termed curl from its characteristic appearance.

We have thus far found it impractical to measure accurately the intensity of leaf-curl attack. As the disease manifests itself in Illinois, it seldom produces any noticeable damage on either the flowers or the fruit, but it occasionally appears in limited regions as a severe twig blight and is everywhere prevalent as a leaf disease. Upon the leaves, it may appear in very small or in large amounts; but it always results in such a curling and malforming of the leaves that we have not been able to devise a workable series of measuring standards with which to gauge its leaf intensity. Consequently, we furnish here only our data on its prevalence.

Data on Leaf-curl

We have obtained an average of 25 records per year on the prevalence of leaf-curl during the years covered by our survey. As shown in Table XVII, these records represent annually an average of 8,879 trees, and the disease is indicated to have an average annual prevalence of 52.02 per cent.

In 1922, when the prevalence of leaf-curl among 5,873 peach trees was shown by the data in 64 records obtained in 27 counties, the index stood at 36.23 per cent. In the following year prevalence increased to the highest point in our record, 95.64 per cent.; but in 1924 it decreased, reaching 19.6 per cent., the lowest point in our records. For 1925 we have no adequate data; but an increase in prevalence to 51.17 was shown by the 15 records taken in 1926; and this tendency to increase was continued into 1927, when on the basis of data contained in 26 records drawn from 21,548 trees the prevalence index was placed at

TABLE XVII
PREVALENCE OF PEACH LEAF-CURL

Year	Prevalence: Percentage of trees having leaf-curl infection	Basis of data		
		Number of records	Number of trees represented by the records	Number of counties represented in the records
1922.....	36.23	64	5,873	27
1923.....	95.64	24	5,950	18
1924.....	19.60	15	1,229	15
1926.....	51.17	15	5,274	8
1927.....	84.97	26	21,548	9
1928.....	24.51	7	13,400	4
Total.....		151	53,274	81
Averages.....	52.02	25	8,879	13

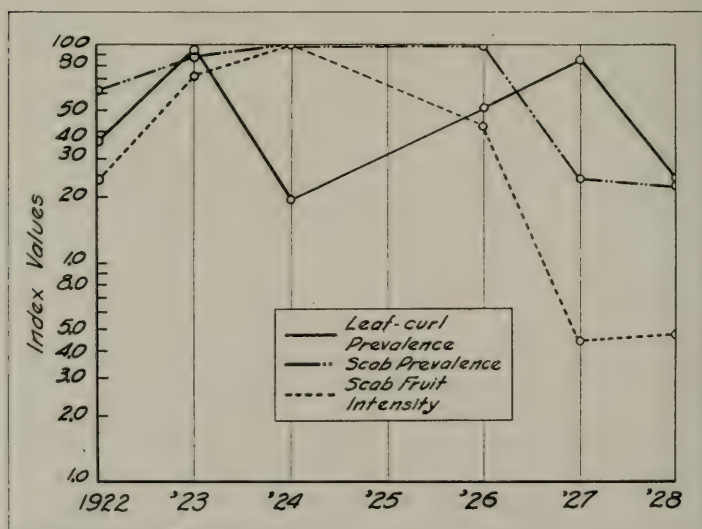


FIG. 21. TRENDS OF THE PREVALENCE OF LEAF-CURL AND OF THE PREVALENCE AND INTENSITY OF SCAB

Data for 1925 are lacking, but the tendency for these diseases to fluctuate sharply from year to year is evident. The high indexes of intensity shown by the fruit attack of scab would be unusual for other diseases but are characteristic of scab.

84.97 per cent. This high level was not maintained, however, for in 1928, when 7 records showed the state of the disease among 13,400 trees located mainly in the worst leaf-curl region of the State, the prevalence index stood only at 24.51 per cent.

The trends of these annual epidemics are shown graphically by the solid line in Figure 21. The tendency to fluctuate sharply from one year to another, which has been apparent with other peach diseases, is also marked in the case of leaf-curl. Though data are lacking for 1925, it is reasonable to suppose that the disease behaved as did most other diseases that year, falling to a very low point of prevalence; and this would give the leaf-curl graph an even more irregular aspect.

PEACH SCAB

Caused by *Cladosporium carpophilum* Thuemen

With its general range including Europe and the entire eastern half of the United States, peach scab is, of course, found commonly throughout Illinois. Like the other peach diseases, it manifests its presence by attacking the twigs, the leaves, and the fruit; but the two phases confined to twigs and leaves are relatively rare and do but little injury to the trees. It is the fruit attack that gives this disease its importance; and as this is its most common manifestation in Illinois, we have chosen to measure the intensity of the annual scab epidemics in terms of infected fruit.

Data on Peach Scab

In all, 122 records of peach scab have been gathered during our survey, an average of 20 per year, representing as an average 14,098 trees per year. As is indicated by the summary of our data given in Table XVIII, the average annual prevalence of the disease in Illinois stands at 66.53 per cent., while its average annual intensity, expressed as the relative proportion of infected peaches, stands at 41.34 per cent. This latter figure does not, of course, indicate the economic loss which results from the disease, since in taking our counts we include all instances of infection, no matter how light they may be.

The annual variations exhibited by the peach scab epidemics are also stated in Table XVIII. In 1922, when a total of 4,097 trees distributed among 16 counties furnished 36 usable records, the prevalence of the disease amounted to 62.68 per cent. and the intensity of the fruit attack to 24.31 per cent. The following year these indexes were found, on the basis of 25 records including 9,673 trees distributed among 18 counties, to have increased quite decidedly, that for prevalence having reached 88.83 per cent. and that for fruit intensity 71.99 per cent. And though in 1924 there were only 9 records representing only 1,526 trees, prevalence continued to rise, reaching the very high index of 100 per cent., which was attained also by the fruit intensity index.

No records are available for 1925; but since the disease entirely escaped the notice of horticultural experts that year, it was probably neither very prevalent nor very destructive. In this, it would have followed the same course that was taken by other peach diseases that year.

In 1926, however, there appears to have been abundant scab infection. Though only 11 records were secured and only 112 trees were represented by them, they were distributed among 6 important peach-growing counties; and the high prevalence index of 100 per cent. and the moderately high fruit intensity index of 42.76 per cent. probably represent the relative state of the disease rather accurately.

In contrast with these years of great prevalence and intensity, 1927 and 1928 stand out as years of mild scab. The six records taken in 1927 apply to orchards containing a total of 4,100 trees and furnish a prevalence index of 24.48 per cent., while in 1928 the 35 records accumulated represent a total of 65,080 trees and give a prevalence index for scab of 23.22 per cent. The indexes indicating the intensity of the scab attack on fruit for these two years were 4.27 per cent. and 4.75 per cent. respectively.

TABLE XVIII
PREVALENCE AND INTENSITY OF PEACH SCAB

Year	Prevalence	Intensity	Basis of data		
	Percentage of trees having scab infection	Percentage of peaches infected by scab	Number of records	Number of trees represented by the records	Number of counties represented in the records
1922.....	62.68	24.31	36	4,097	16
1923.....	88.83	71.99	25	9,673	18
1924.....	100.00	100.00	9	1,526	9
1926.....	100.00	42.76	11	112	6
1927.....	24.48	4.27	6	4,100	2
1928.....	23.22	4.75	35	65,080	10
Total.....			122	84,588	61
Averages.....	66.53	41.34	20	14,098	10

The trends of the prevalence and fruit intensity indexes of peach scab are shown graphically by the broken lines in Figure 21. Discounting the false trend indicated, through lack of data in 1925, as occurring between 1924 and 1926, the curves for both the prevalence and the fruit intensity indexes follow essentially the same trend from year to year. It is notable that this disease does not fluctuate so sharply from one year to another as do other peach diseases. Rather, from the beginning of our record through 1926, it appears to have followed a rather even, high course (though, of course, we cannot state the actual trends for 1925), while during the last two years, 1927 and 1928, it has maintained a similar even course, though at a lower level.

SUMMARY OF PEACH DISEASE DATA

In the preceding discussion of peach diseases the data gathered each year for each disease have been given in tabular summaries, and comparisons have been made of the prevalence and intensity of each disease.

Prevalence of Peach Diseases

In Table XIX, the annual indexes of prevalence for the several peach diseases have been brought together so that the diseases may be compared with one another.

In the first year of our survey, brown-rot stands out as the most prevalent of the peach diseases, but the bacterial shot-hole disease and scab also had high indexes, while leaf-curl occupied the lowest position. For 1922, the average incidence of diseases per tree was 2.67. In 1923, the diseases formerly occupying first and last places changed positions

TABLE XIX
SUMMARY OF PREVALENCE OF PEACH DISEASES

Diseases	1922	1923	1924	1925	1926	1927	1928
Brown-rot.....	88.24	25.22	97.41	trace	9.26	55.88	22.68
Bacterial shot-hole....	79.62	59.59	95.52	14.54	93.98	99.09	97.47
Leaf-curl.....	36.23	95.64	19.60	.....	51.17	84.97	24.51
Scab.....	62.68	88.83	100.00	.....	100.00	24.48	23.22
Average incidence of disease per tree.....	2.67	2.69	3.12	.14	2.54	2.64	1.68

so that leaf-curl held first place and brown-rot last place. Scab was second in the order of prevalence and bacterial shot-hole was third, while the average incidence of diseases per tree rose very slightly to 2.69. Scab attained first rank in prevalence in 1924, with brown-rot and shot-hole also having indexes of 95 per cent. or more, but leaf-curl attained only the slight prevalence of 19.6 per cent. For this year the average incidence of disease was 3.12 per tree, the highest point reached in the period of our records.

The year 1925 probably ought to stand out more strikingly than it does, with the indexes for two diseases missing, as a year of very little disease. Brown-rot, usually a distinct menace to the peach crop, was so rare that its prevalence could be described only as a trace while the bacterial shot-hole disease exhibited the exceptionally small index of 14.54 per cent.

All diseases showed an increase in prevalence in 1926, but scab and bacterial shot-hole were most successful, while brown-rot was still of minor importance; and the average incidence of diseases per tree amounted only to 2.54. In 1927 brown-rot, shot-hole, and leaf-curl practically attained to their former states, but scab fell off in prevalence

to a very low point. The average incidence of diseases per tree attained the high point, 2.64.

In 1928 bacterial shot-hole was the only disease exhibiting a high degree of prevalence. Brown-rot fell off markedly, and so also did leaf-curl, while scab remained at essentially the level of the year before. Consequently, the average incidence of disease per tree fell to 1.68, the lowest point in our record with the exception of the incomplete 1925.

The trends of prevalence for each of the peach diseases are shown in the lower part of Figure 22, and the trend from year to year of the average incidence of diseases is shown in the upper part. From 1922 to

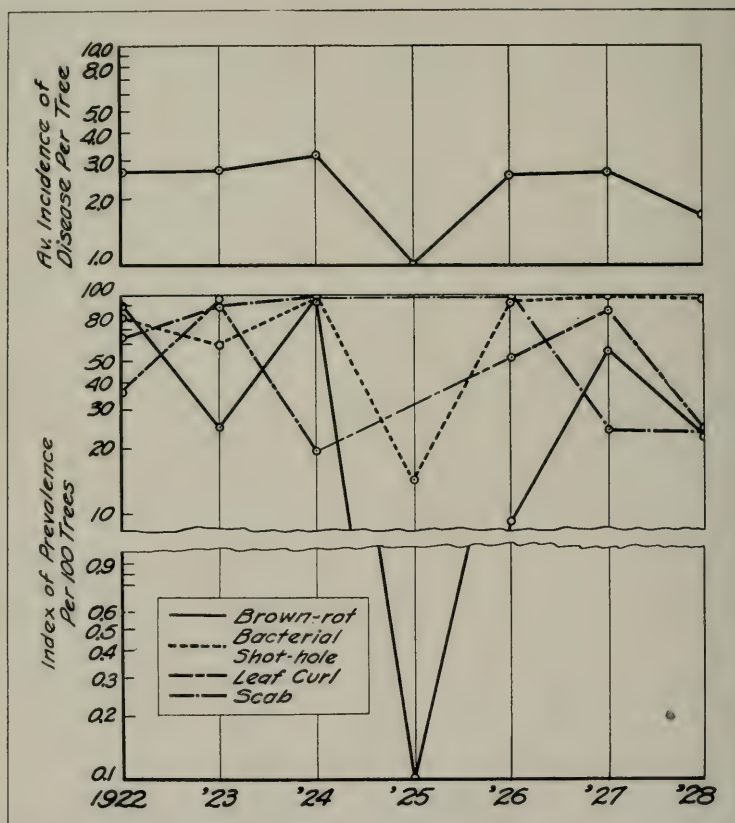


FIG. 22. COMPARISON OF THE PREVALENCE TRENDS OF PEACH DISEASES

The lower part of the figure gives the trends for each disease and the upper part the trend of average annual incidence of disease per tree. The break in the lower part is necessary to show the great drop in brown-rot prevalence in 1925. Data for 1925 are lacking for leaf-curl and scab.

1923 the trends of leaf-curl and scab moved upward, but this was counterbalanced by a downward movement by brown-rot and shot-hole, with the result that the level of average incidence was scarcely changed.

The upward movement of scab was continued into 1924, and brown-rot and shot-hole both reversed their downward trends, as did

leaf-curl its upward trend, with the result that, in spite of the steep fall of leaf-curl, the trend of average incidence was turned distinctly upward.

Partly through lack of data for two diseases, but more evidently because the year was very unfavorable to peach diseases, as is indicated by the steep falls of the brown-rot and shot-hole trend lines from 1924 to 1926, the average incidence curve was bent down very sharply in 1925. With all four diseases tending to increase their prevalence in 1926, the average incidence line returned again to nearly a normal level; and with the continued rise in the trends of brown-rot, leaf-curl, and shot-hole, the incidence curve rose a trifle higher in 1927 and was held to a level slightly below that of the 1922 only by the sharp decline of scab. Between 1927 and 1928 all trends were downward, those of brown-rot and leaf-curl very distinctly so, those of scab and shot-hole perceptibly so, with the result that the trend of average incidence moved downward also.

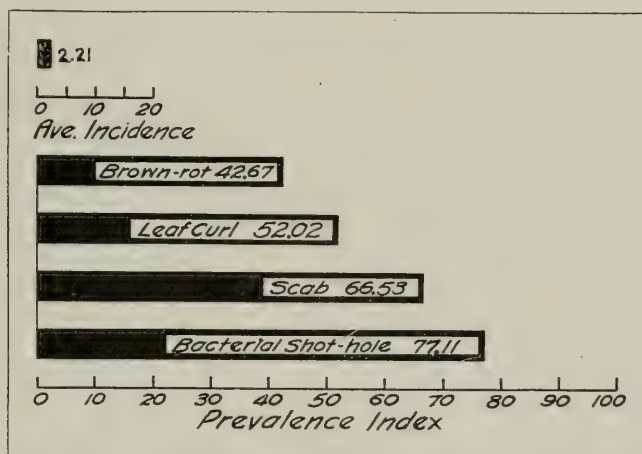


FIG. 23. COMPARISON OF THE AVERAGE ANNUAL PREVALENCE OF PEACH DISEASES

Brown-rot is prevalent to the least extent and bacterial shot-hole to the greatest, while leaf-curl and scab are intermediate. These four diseases, by their combined attack, give an average annual incidence of disease of 2.21 per tree.

There appears to be but little agreement among peach diseases as to their prevalence reaction in ordinary years. While certain ones may move together in one year they are apt to move in opposite directions in another year. Each disease appears to be influenced to a marked degree, either favorably or unfavorably, by changes in some one or more factors in the environment provided from year to year. It is notable, however, that in spite of the great fluctuations exhibited by the individual diseases, their various reactions result, on the whole, in maintaining the curve for the average incidence of disease at a surprisingly uniform level.

By summing the annual indexes of prevalence for each disease and apportioning this sum equally among all the years for which we have records, a statement may be obtained of the average prevalence of each disease over a period of years. This is illustrated in Figure 23. Brown-rot is shown to be, on an average, the least prevalent of the peach diseases, having an average annual prevalence index of 42.67 per cent. Leaf-curl, with its average annual prevalence index of 52.02 per cent., is approximately one and one-fifth times as prevalent as brown-rot; scab, with its average index of 66.53 per cent. is one and a half times as prevalent as brown-rot; and bacterial shot-hole, with an average index of 77.11 per cent., is one and four-fifths times as prevalent as brown-rot.

The average incidence of peach diseases per tree, as indicated in Figure 23, is 2.21.

Intensity of Peach Diseases

Owing to the fact that in our survey of peach diseases we have not, as a rule, measured the intensity of any one disease by more than one of its various manifestations, we shall not attempt to make the same variety of comparisons that were made with the apple diseases. But in order to make as complete a statement as possible, we shall introduce some data on types of intensity not given in the previous discussion. These data, as will be seen by examining Table XX, show the results of our observations on the intensity of the fruit attack of the bacterial shot-hole disease in 1927 and 1928, the intensity of the twig attack of brown-rot in 1926, 1927, and 1928, and the intensity of the twig attack of leaf-curl for all years except 1925 when no data were taken. We do not believe, however, that the twig intensity indexes for leaf-curl for the years prior to 1926 are sufficiently accurate to indicate in more than a relative way the intensity of the disease.

TABLE XX
SUMMARY OF INTENSITY OF PEACH DISEASES

Diseases	1922	1923	1924	1925	1926	1927	1928	Averages
On fruit:								
Brown-rot.....	2.29	.53	27.36	trace	trace	8.47	1.52	5.73
Scab.....	24.31	71.99	100.00	.....	42.76	4.27	4.75	41.34
Shot-hole.....						13.78	31.20	22.49
On twigs:								
Brown-rot.....					.05	5.18	.61	1.94
Leaf-curl.....	3.43	22.78	4.70	.....	3.98	10.20	3.36	8.07
On leaves:								
Shot-hole.....	2.21	1.27	53.53	.01	8.41	4.07	2.87	10.33

Always bearing in mind the limitations of accuracy that affect these data, the material given in Table XX can be rearranged graphically, as is done in Figure 24, to show the variations in total annual intensity of the peach diseases. The table included in this figure gives by years the totals of the annual intensity indexes of all diseases, as listed in Table XX, for each type of disease manifestation, and these totals are represented graphically by the blocks in the diagram. Hence, each year's block shows in black the percentage of fruit infected by all diseases, by cross-hatching the percentage of twigs infected by all diseases, and by vertical shading the total percentage of leaf-area occupied by disease lesions.

The year 1924 stands out as the year of most intense disease epidemics; but 1925, though following immediately, had the least intense

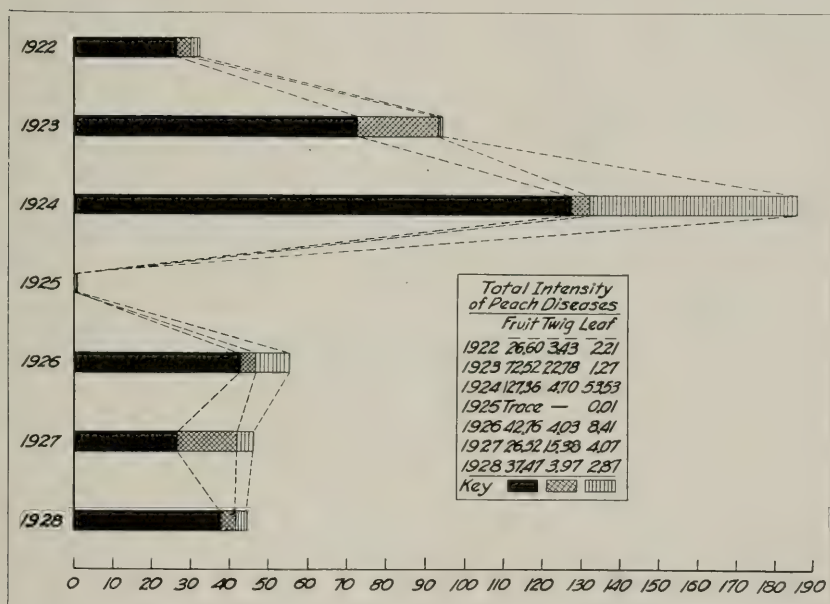


FIG. 24. COMPARISON OF THE TOTAL INTENSITY OF PEACH DISEASES BY YEARS

The table in the chart gives the sums of the indexes of fruit, twig, and leaf intensity of all diseases, and these sums are shown graphically by bars for each year. See text for further explanation.

epidemics. All phases of intensity vary from year to year; but that on fruit, though varying to a greater extent than any other, has always been the most important. Excepting in 1924 and 1926, twig intensity was of more importance than leaf intensity, but it is readily seen that in the 1924 block fruit intensity and leaf intensity make up by far the greater part, as is true also of the 1926 block.

Through 1924, peach diseases appear to have been increasing very rapidly in the intensity of their epidemics; but with the advent of the universally unfavorable 1925 all epidemics appeared in mild form. Sub-

sequently, however, peach diseases increased the intensity of their attacks and attained a level in 1926, 1927, and 1928 somewhat higher than they had occupied in 1922.

It is worthy of note that the tendency of peach disease to attack fruit to a greater extent than any other part of the tree gives them an especial importance, inasmuch as they are therefore an annual threat against the harvesting of an abundant and profitable crop.

The average comparative intensities of each of the peach diseases, as they have manifest themselves during the period covered by our survey and as they probably may be expected to manifest themselves over a similar period of years, are shown by the table and diagrams in Figure 25. In the table, the figures show the averages of the annual intensity indexes of each disease for each of its measured manifestations, and these values are shown diagrammatically for easy comparison by the horizontal shaded blocks.

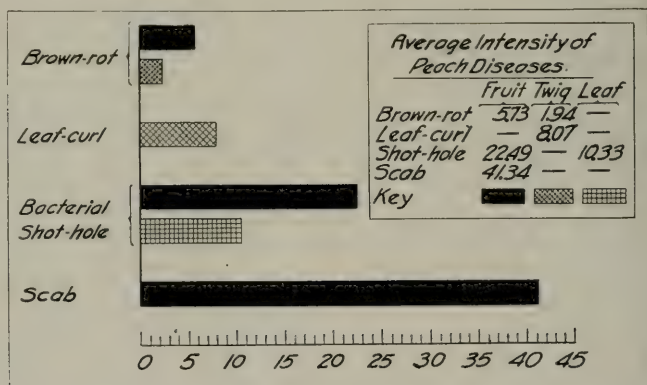


FIG. 25. COMPARISON OF THE AVERAGE ANNUAL INTENSITY OF PEACH DISEASES

The table gives the average annual intensity index for each measured manifestation of each peach disease and the length of the bars expresses these indexes graphically. For further explanation see text.

Brown-rot, though it has been measured in terms of fruit intensity and twig intensity, does not equal any other diseases in either of these respects; and its epidemics may therefore be considered the mildest from the disease standpoint, though not from the commercial, of any of the peach diseases. Leaf-curl, the intensity of which we have measured only in terms of diseased young growth, exceeds in this respect brown-rot, and the two diseases combine to furnish almost the total amount of twig destruction. Bacterial shot-hole, for which indexes have been computed to show the intensity of attack on fruit and leaves, exceeds brown-rot by nearly four times in its fruit intensity and contributes almost the entire amount of leaf area reduction not attributable to the attack of leaf-curl. Scab, which we have measured only as a fruit disease, exhibits the greatest average intensity of attack of any of the peach diseases.

The comparisons made in Figure 24 ought not, however, to be understood as in any way representing the relative commercial importance of the peach diseases. Brown-rot, ranked on the basis of our data as least important in the intensity of its epidemics, is the most important commercially of the four; and bacterial shot-hole, shown by our diagram to be milder in its epidemics than scab, usually out-ranks scab very greatly in its injurious effects upon the peach crop. This, however, only serves to emphasize the necessity of considering the disease separately from its effects on yield, if data are to be useful in explaining the annual fluctuations in prevalence of disease and in intensity of disease attack.

CHERRY AND PLUM DISEASES

As was pointed out in our discussion of the distribution of fruit trees in Illinois, neither cherries nor plums are grown as extensively as apples and peaches. For the most part, they are to be found in small groups in farm orchards, though there are of course larger plantations of a hundred trees or more scattered here and there through the State. As a consequence, these fruit trees do not in general receive the same care, either in cultivation or in spraying, as the more important kinds of fruit trees; and this naturally results in a greater prevalence of disease and usually in a greater intensity of disease attack.

The epidemic diseases of cherries and of plums are similar. Brown-rot, previously discussed as an important peach disease, also attacks both cherries and plums. The bacterial shot-hole disease of peaches is very common on plums and is occasionally encountered on cherries. Both cherries and plums suffer also from leaf-spot injury resulting from the attack of fungi classed as species of *Coccomyces*.

In measuring the annual epidemics of cherry and plum diseases, we have taken into account both prevalence and intensity; but owing to the abundance of disease upon the leaves, we have distinguished in our records only brown-rot and leaf spotting, including in the latter category all types of leaf spotting, without regard to cause. Figure 26 shows the scale we have used in estimating the leaf-area occupied or destroyed by leaf-spot diseases of cherries, and Figure 27 shows the scale we have used for plum leaf spotting.

Data on Cherry and Plum Diseases

During the period covered by our survey, we have secured data on the diseases of plums and cherries more or less incidentally as we carried on our work with the diseases of more important commercial crops. Nevertheless in 1922, 1923, and 1924 data were obtained on brown-rot attack from a total of 2,127 cherry trees; in the years 1922-1924 and 1926 and 1927, data on brown-rot were secured from 1,069 plum trees; and through the period of the survey data on cherry leaf spotting was taken from a total of 10,796 trees and on plum leaf spotting from a total of 408 trees. The results of these examinations are summarized in Table XXI.

In 1922 the brown-rot epidemic on cherries was very light. The prevalence of the disease had the very low index of 12.17 per cent.,

while the intensity of its attack on fruit was only 1.12 per cent. But in 1923 the epidemic was severe, prevalence then rising to 100 per cent. and intensity to 17.21 per cent. In the following year, 1924, there was no appreciable reduction in brown-rot prevalence. The index for that year stood at 99.94 per cent., a reduction of only .06 per cent. from 1923; but the intensity of brown-rot attack on the fruit increased to 29.05 per cent.

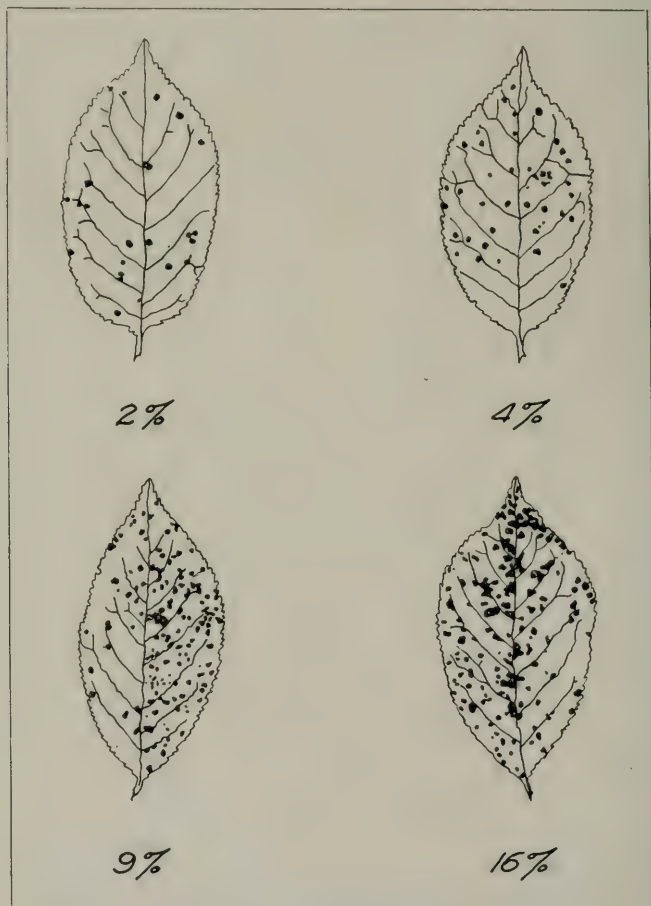


FIG. 26. SCALE FOR ESTIMATING THE INTENSITY OF SPOTTING ON CHERRY LEAVES

In each example the area of the spots is expressed as a percentage of the area of the leaf. No effort is made in using this scale to distinguish between leaf-spots resulting from different causes.

Though these three are the only years of the period covered by our survey for which we have representative data, they serve to indicate the importance of brown-rot as a cherry disease. With an average an-

nual prevalence of 70.7 per cent. and an average annual index of fruit intensity amounting to 15.79 per cent., this disease is annually a menace to cherry production.

Leaf spotting of cherry trees, as may be seen in Table XXI, always has a high prevalence. In 1922 its prevalence index was 92.66 per cent., in 1924 it was 99.35 per cent., and in all other years except



FIG. 27. SCALE FOR MEASURING THE INTENSITY OF SPOTTING ON PLUM LEAVES

In each example the area of the spots is expressed as a percentage of the area of the leaf. This scale measures roughly the combined intensity of the bacterial shot-hole and coccomyces leaf-spot lesions.

1925, for which we have no adequate data, it was computed to be 100 per cent. Its prevalence in Illinois, as exemplified by our data for six years, averages annually 98.66 per cent.

There is, however, a very considerable annual variation in the intensity of cherry leaf spotting. In 1922 the index of intensity stood at .55 per cent.; in 1923 it rose to 1.97 per cent., nearly four times the previous amount; and in 1924 it rose still further, reaching 4.65 per cent. No data are available for 1925, but the index for 1926, 2.28 per cent., suggests that leaf spotting in common with several diseases of other fruit trees, may have decreased very considerably. The year 1927 is remarkable for the exceptionally intense attack of leaf spotting diseases on cherries. The index for that year, 15.69 per cent., the highest we have recorded, is merely three and a half times as great as the previous high index of 4.65 per cent. recorded in 1924. It is rather surprising, after so intense an attack, to find the index of intensity falling in the next year, 1928, to so small an amount as .69 per cent., but this serves to emphasize once more the tendency of diseases to fluctuate greatly from one year to another, under the influence of varying weather conditions.

TABLE XXI
PREVALENCE AND INTENSITY OF CHERRY AND PLUM DISEASES

Diseases	1922	1923	1924	1925	1926	1927	1928	Average
Prevalence on cherries:								
Brown-rot.....	12.17	100.00	99.94	.....	.....	.....	.....	70.70
Leaf-spotting.....	92.66	100.00	99.35	.....	100.00	100.00	100.00	98.66
Intensity on cherries:								
Brown-rot.....	1.12	17.21	29.05	.....	.....	.....	.....	15.79
Leaf spotting.....	.55	1.97	4.65	.....	2.28	15.69	.69	4.30
Prevalence on plums:								
Brown-rot.....	84.61	97.64	100.00	.....	100.00	100.00	100.00	97.04
Leaf-spotting.....	95.58	100.00	96.49	.....	.....	.....	.....	97.36
Intensity on plums:								
Brown-rot.....	9.21	49.00	29.42	.....	80.00	25.00	.....	38.52
Leaf-spotting.....	1.53	6.71	4.80	.....	.....	.....	.....	4.35

The six epidemics represented by our data indicate an average annual intensity for the leaf spotting diseases of cherries of 4.3 per cent. This index may, however, be a little high, because of the lack of data for 1925, a year generally characterized by low intensity of disease attack.

On plums, brown-rot appears to be even more prevalent and destructive than on cherries. Its index of prevalence in 1922, as stated in Table XXI, was 84.61 per cent.; in 1923 it was 97.64 per cent.; and in each of the years 1924, 1926, and 1927 it was 100 per cent. The average annual prevalence of brown-rot on plums, as computed by averaging these indexes, is 97.04 per cent., one and one half times as prevalent as our data show the disease to be on cherries.

In the intensity of its attack on fruit, brown-rot is also a destructive disease of plums. Beginning with an intensity index of 9.21 in 1922, the

disease increased in severity in 1923 to the point of attaining an index of 49 per cent. Though this high percentage of fruit disease fell off to the not very moderate amount of 29.42 per cent. in 1924, the attack again attained such serious proportions in 1926 that the intensity index stood at 80 per cent. This was reduced in 1927 to 25 per cent.; but the seriousness of plum brown-rot as an annual menace to the plum crop is well expressed by its average annual fruit intensity index of 38.52 per cent.

Leaf spotting of plums appears in our records only for the years 1922, 1923, and 1924. In the first of these years its prevalence among the plum trees examined was 95.58 per cent.; in 1923 it was 100 per cent.; and in 1924 it fell slightly to 96.49 per cent. Its average annual prevalence, as indicated by these three indexes, is 97.36 per cent.

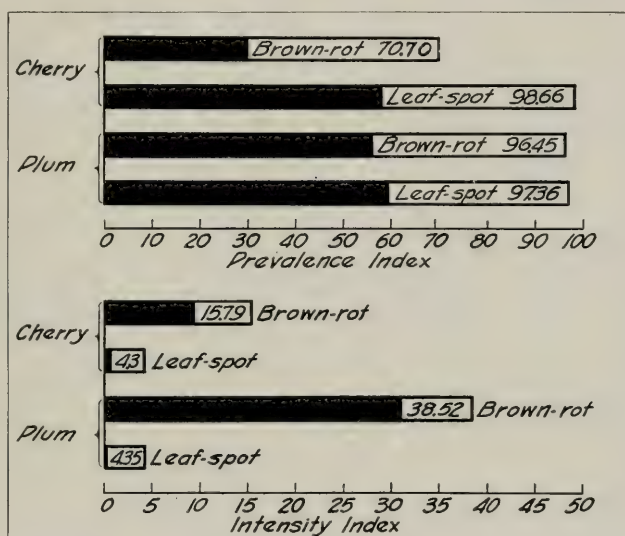


FIG. 28. COMPARISON OF THE AVERAGE ANNUAL PREVALENCE AND INTENSITY OF CHERRY AND PLUM DISEASES

Brown-rot is less prevalent on cherries than on plums but leaf spotting is nearly equally prevalent on both. In intensity brown-rot is more severe on both cherries and plums than is leaf spotting. The intensity of leaf spotting is nearly equal on both fruits. (Brown-rot prevalence should read 97.04 instead of 96.45. See Table XXI.)

The intensity of the leaf-spot diseases for these years is shown in Table XXI as 1.53 per cent. in 1922, 6.71 per cent. in 1923, and 4.8 per cent. in 1924. These three indexes indicate an average annual intensity of 4.35 per cent.

The average annual prevalence and intensity of the cherry and plum diseases are compared graphically in Figure 28. Brown-rot may be seen to be less prevalent on cherries than on plums and much less prevalent on cherries than is the leaf spot either on cherries or plums. On plums, brown-rot and leaf spotting are nearly equally prevalent.

In the average intensity of its attack on cherries, as illustrated in Figure 28, brown-rot exceeds leaf spotting, but is less than one-half as severe as it is on plums. There is little difference between the average intensities of leaf spotting on cherries and on plums.

SUMMARY OF DATA

In our detailed discussion, the methods employed in taking data on fruit-tree diseases have been described; the simple statistical methods used in evaluating these data have been explained; and the results of our annual surveys of fruit-tree diseases, determined by this statistical treatment, have been presented in a manner designed to show with exactness the year-by-year variations in the prevalence and severity phases, as well as the average condition, for each important epidemic disease of each kind of fruit tree. These results, being based, without exception, upon separate percentage calculations for every phase of disease attack, are entirely comparable, whether comparisons be made between the indexes of one disease for different years or between the indexes of different diseases of the same or of different kinds of trees. The only limitation that can be placed upon these comparisons arises from natural and unavoidable variations in the quantity and dependability of field data; but these matters can readily be tested and evaluated by several well-known statistical indicators, such as the standard deviation or the probable error.

It now remains to present, from these same data, a general picture of fruit-tree disease, in which the total effect of disease can be clearly seen, in its year-to-year variations and in its average condition, upon each kind of fruit tree. In so doing, the mass of detail given earlier must be combined as much as possible; but it is still desirable to maintain, both for clearness and because of the impossibility of uniting the several modes of disease attack in one inclusive measurement, the distinctions we have made not only between prevalence and intensity but also between fruit disease, twig disease, and leaf disease.

We have enumerated for apples five separate epidemic diseases; for pears, one disease; for peaches, four; and for cherries and plums, two each. Fruit trees, like other living things, are not rendered immune to further maladies by becoming infected with one disease. As every orchardist knows, an apple tree may suffer from scab alone, from blotch alone, or from both, and even from blight, black rot, and rust also. So it may readily be understood that if the several sets of indexes of all the diseases of one kind of fruit-tree for any one year are added together their totals will show the amount of disease on the average tree.

ANNUAL PREVALENCE OF FRUIT-TREE DISEASES

For apple diseases in 1922, the scab index for prevalence of 93, the black rot index of 65.64, the blotch index of 53.03, the fire blight index of 42.64, and the rust index of 26.29, when added, give a total of 280.60. This at first suggests what is apparently unreasonable, that in every 100 trees the percentage of diseased trees was 280.6; but actually the meaning is that, on an average, in every 100 trees there were about 281 cases

of disease, when the separate kinds of disease are recognized. An equally concrete, perhaps a more easily understood statement of the same fact is that the individual tree was attacked on an average by 2.8 diseases. The sums of prevalence indexes, when regarded in this way, are an expression of the number of cases of disease per 100 trees, and by dividing this by 100 we obtain a number which we may very properly term the average incidence of disease per tree.

The average incidence of disease per tree, because of the manner in which it is derived, expresses briefly and accurately the prevalence of disease in any year or, by an average of years, for any desired longer period of time.

In Table XXII the average incidence of disease per tree, derived by totaling the prevalence indexes given previously for the several dis-

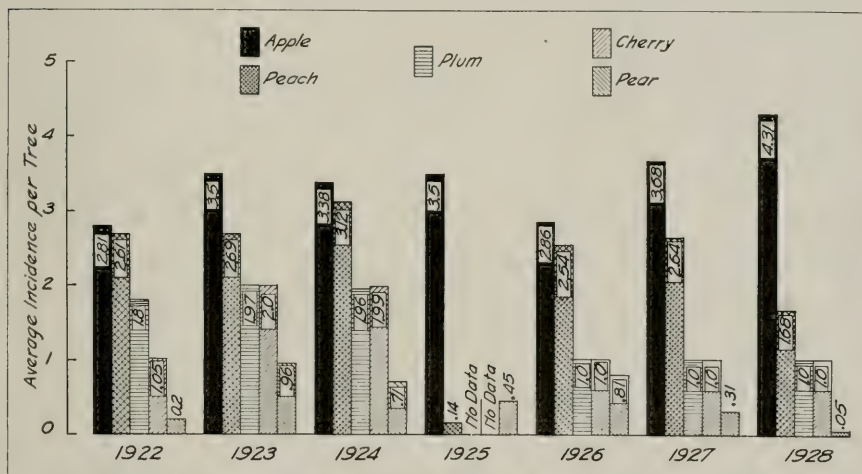


FIG. 29. COMPARISON OF THE ANNUAL INCIDENCE OF DISEASE PER TREE FOR EACH OF THE FIVE TREE FRUITS

Apples are most subject to disease attack every year and peaches are next. Plums and cherries are nearly equally subjected to attack, and pears less than any. This ranking on the basis of disease prevalence would not, however, correspond to a ranking on the basis of commercial injury.

TABLE XXII

AVERAGE INCIDENCE OF DISEASES PER TREE

Kind of tree	1922	1923	1924	1925	1926	1927	1928
Apple.....	2.81	3.50	3.38	3.50	2.86	3.68	4.27
Pear.....	.20	.96	.71	.45	.81	.31	.05
Peach.....	2.67	2.69	3.12	.14	2.54	2.64	1.68
Cherry.....	1.05	2.00	1.99	.....	1.00	1.00	1.00
Plum.....	1.80	1.97	1.96	.....	1.00	1.00	1.00

eases and dividing the sum by 100, is given by years for each of the five kinds of fruit trees dealt with.

Upon comparing the items in this table it will be found that the apple and the peach, our two most important horticultural crops, succumb quite consistently to the attack of more diseases than do the less important pear, cherry, and plum. It may be seen also that the total of disease prevalence fluctuates from year to year just as noticeably as the prevalences of single diseases.

The data tabulated in Table XXII are shown graphically in Figure 29. The height of the columns represents the average incidence of disease per tree. It is evident that of the five kinds of fruit trees important in Illinois horticulture, the apple has in every year been most subject to the attack of epidemic diseases. In comparison with other kinds of fruit trees, the prevalence of disease on the apple has varied the least from year to year. The peach, next to the apple, has been most subject to disease attack; but the prevalence of disease among peach trees has varied to a far greater extent from year to year than it has among apple trees. The plum and the cherry, being as a rule susceptible to the same diseases, have been subjected almost equally to disease attack, though the actual prevalence of disease may be greater on one in one year and on the other in an other year. With pears, for which in our state there is but one generally severe epidemic disease, the columns in Fig. 29 serve only to represent its annual fluctuations in prevalence.

ANNUAL INTENSITY OF DISEASE ATTACK

Intensity of attack, as our discussion of the individual diseases has suggested, is in many respects distinct from disease prevalence and, as it has been measured separately throughout our surveys, it should be maintained separately in our summary.

In order to determine, for each kind of fruit, to what extent the intensity of attack of all the epidemic diseases affects the average tree, it is necessary to add together in separate categories the annual indexes for fruit disease, for leaf disease, and for twig disease determined from the field data. The results may then be regarded as showing the annual intensity of disease attack on the average tree. This summation is given in Table XXIII. The total intensity of disease attack on the apple is shown for the fruit, twig, and leaf, on the pear for twig-disease only, on the peach for fruit, twig, and leaf, and on the cherry and plum only for the fruit and leaf disease.

For clearer presentation and more ready comparison, these data are given graphically in Figure 30. The intensity of the various phases of disease for the several kinds of fruit trees is shown year by year. The first column of bars relates to intensity of attack on fruit, the second to intensity on twigs, and the third to the intensity of leaf disease.

Intensity of Disease on the Fruit

Fruit intensity data in Table XXIII apply only to apples, peaches, cherries, and plums. The bars representing these data in Figure 30 are

arranged for each year in the order in which the fruit were named. In the years 1922, 1923, and 1924, the intensity of fruit disease on apples, shown by black bars, tended to decrease, while fruit diseases on peaches, shown by doubly cross-hatched bars, tended to increase. This opposition of trends is of interest, not only because it suggests a possible general and opposite difference in the effect of weather conditions upon apple and peach fruit-diseases but also because the general increase in fruit disease intensity on cherries and plums in the same years indicates that conditions increasingly unfavorable to diseases on pomaceous fruits may be increasingly favorable to diseases attacking fruits of drupaceous trees.

The year 1925 is outstanding because of the very slight intensity of disease attack on fruit, but in the succeeding years, 1926, 1927, and 1928, the attack on fruit is shown to have increased again in the case of every kind of fruit tree for which data were obtained. And in these

TABLE XXIII
INTENSITY OF DISEASE ATTACK ON FRUIT TREES

Kind of fruit	1922	1923	1924	1925	1926	1927	1928
Apple:							
Fruit.....	79.61	69.83	29.46	9.09	12.66	24.71	19.73
Twig.....	13.45	91.35	21.36	59.30	4.49	7.68	6.64
Leaf.....	12.62	22.22	7.42	3.24	15.02	2.16	2.99
Pear:							
Twig.....	1.59	18.44	20.53	5.61	14.21	2.31	.16
Peach:							
Fruit.....	26.60	72.52	127.36	trace	42.76	26.52	37.47
Twig.....	3.43	22.78	4.70		4.03	15.38	3.97
Leaf.....	2.21	1.27	53.53		8.41	4.07	2.87
Cherry:							
Fruit.....	1.12	17.21	29.05				
Leaf.....	.55	1.97	4.65		2.28	15.69	.69
Plum:							
Fruit.....	9.21	49.00	29.42		80.00	25.00	
Leaf.....	1.53	6.71	4.80				

years it is again observable that seasons not particularly favorable to the development of apple fruit-disease appear to favor the development of disease on drupes.

In 1926 there was an increase in apple fruit-disease intensity over 1925, but the smallness of this increase indicates a season generally unfavorable. It is notable that in this same year peach fruit-disease increased very remarkably in intensity, while plum fruit-disease attack reached the highest intensity recorded in our data. Accompanying the increase in apple fruit-disease intensity shown for 1927, there was a decided diminution in the intensity of disease attack on the fruits of both peach and plum; and in 1928, with the lessened intensity of apple fruit-disease, there again occurred an increase in the intensity of the fruit-attacking peach diseases.

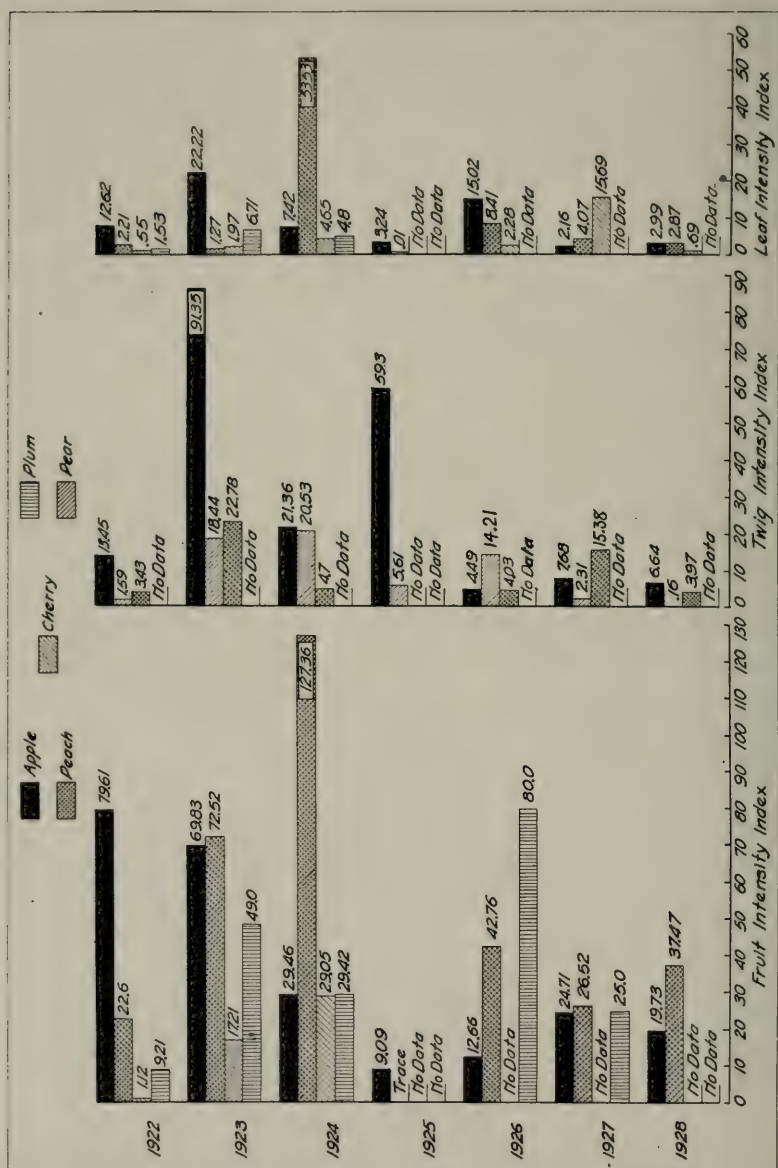


FIG. 30. COMPARISON OF THE ANNUAL INTENSITY OF DISEASE ON EACH OF THE FIVE TREE FRUITS

The bars in the column at the left compare fruit intensity by years, those in the middle column twig intensity, and those in the column at the right leaf intensity. For further explanation, see the text.

The causes of this oppositeness of reaction exhibited by the diseases of pomaceous and drupaceous fruits may be sought for in the weather which prevailed during those periods when the distinctly different diseases of the two types of fruits were developing.

Intensity of Twig Disease

Data on intensity of twig-disease are given in Table XXIII for each kind of tree for which they are available. These data are shown graphically by the middle column of bars in Figure 30. Data have been obtained for twig-disease of apples, pears, and peaches. The bars in Figure 30 are arranged in this order. The blank spaces marked "no data" indicate the absence of twig-disease data for the plum and cherry, except for 1925 when data were also lacking for peaches.

The fluctuations from year to year in intensity of disease attack on twigs are more generally in agreement for all kinds of fruit trees than was the case with fruit-disease. In 1922, indexes for twig-disease intensity were relatively low for apples, pears, and peaches, but in 1923 they increased, that for apples very greatly and those for pears and peaches to a lesser extent. In 1924 the twig-disease intensity indexes for the apple and the peach fell, that for the peach nearly to the level of 1922, while the index for pears rose somewhat above its 1923 level. The year 1925, conspicuous for its detrimental influence upon fruit and leaf infection, allowed the twig-disease intensity index for apples to reach a very high point, but at the same time the pear index dropped to about one-fourth its former value. Lacking data, the trend of the peach index cannot be determined. In the following years, 1926, 1927, and 1928, all indexes for the intensity of twig disease are low, and it may be assumed from this that 1925 eventually proved as detrimental to this form of disease as it was to other forms, though the effect was manifested later. The small increases and decreases of the twig-disease indexes manifested from year to year in this last period of our survey are followed consistently by the diseases of apple and peach, and no distinction can be made between the twig-disease trends of drupaceous and pomaceous trees. They appear to react uniformly to weather conditions.

Intensity of Leaf Disease

The totaled indexes of leaf-disease intensity are given in Table XXIII and are shown graphically by the third column of bars in Figure 30. Data are available for leaf-disease on apples, peaches, cherries, and plums, and the bars in Figure 30 which represent these data for each year are arranged in the order in which the fruits have just been named. Intensity of leaf-disease attack was low for all fruits in 1922. There is, however, no observable subsequent general tendency toward increase. In 1923, apple leaf-disease increased in intensity, peach leaf-disease decreased, and leaf-disease on both cherry and plum increased. In 1924, a marked falling off in the intensity of apple leaf-disease by two-thirds of its former amount was accompanied by an even more remarkable increase in peach leaf-disease intensity, while the corresponding index for cherries increased and that for plums decreased.

The year 1925 was very severe in its effect on leaf-disease, reducing the index for apple to a low point but being apparently more favorable to apply diseases than to peach diseases, as the latter was too slight to measure. With 1926, the leaf-disease intensity indexes rose again, those for the peach and the cherry increasing to moderate points and that for the apple rising above its 1922 level. In 1927, the rearrangement of these indexes placed that for cherry highest, with the peach index intermediate and that for apple lowest. There were no data upon which to base an index for plum leaf-disease. In 1928, the apple index rose slightly above its previous level, the peach index was diminished to about three-fourths of its former value, and the cherry index fell to the lowest recorded point.

In the fluctuations of the yearly indexes of intensity for disease attack there is no complete agreement, but it is worthy of note that the tendency to move in opposite directions previously demonstrated by the indexes of fruit-disease intensity for the apple and peach is again well defined in the movements of the leaf-disease indexes of these trees. From 1922 to 1923 the change in the leaf-disease intensity index for apple was upward, the change in the peach index downward; from 1923 to 1924 the apple index moved downward, the peach index upward; the indexes of both trees suffered great reductions in the disastrous season of 1925 (though the apple index was affected less than the peach index); the very considerable increase in the apple index in 1926 was accompanied by similar increase in the peach index; in 1927 a great decrease in the apple index was accompanied by a decrease only half as great in the peach index; and in 1928 the slight increase in the apple index was again contrary to the decrease in the peach index.

There is, not, in this case, the completeness of opposing trends that was exhibited by the intensity indexes for fruit-disease, and the movements of the leaf-disease indexes for the cherry and plum do not uphold a consistent difference in trends between leaf-disease on drupaceous and on pomaceous trees; but it does appear that seasons favoring intense leaf-disease attack on apple trees are adverse to the development of leaf-disease on peaches.

AVERAGE PREVALENCE AND AVERAGE INTENSITY OF FRUIT-TREE DISEASES

In summarizing our data on the prevalence and intensity of attack exhibited by the individual diseases of each kind of fruit-tree, we have computed for each disease a set of indexes to show its average annual prevalence and intensity through the period of our survey, and from these averaged indexes we have also computed indexes which express numerically the average annual incidence of disease per tree and the average annual intensity of disease attack on fruit, twig, and leaf for each kind of fruit tree. These final indexes are all brought together in Table XXIV, and the values there shown are given graphical expression in Figure 31.

As would naturally be expected from the fact that it is subject to attack by the largest number of epidemic diseases, the apple has the highest average disease incidence per tree. The peach ranks second in

this respect, the plum third, the cherry fourth, and the pear, with its one important disease, fifth. But it is interesting to find that in susceptibility to disease attack the apple also ranks first, and this is true in spite of the larger number of apple diseases. On an average, an apple disease succeeds in attacking 68 or 69 out of every 100 trees, while a peach disease succeeds in attacking only 55 trees in a hundred. The average susceptibility of the plum and cherry to disease attack appears rather high when the figures given in Table XXIV are interpreted strictly, being respectively 67 and 77 trees per 100; but since the leaf spot disease, as recognized in the accumulation of data, is in each case really a composite of two diseases, their apparent susceptibility is reduced thereby to about 44 and 48 trees per 100, respectively, or less than the susceptibility of the peach. From the graphical presentation of data in Figure 31, it may be seen that the differences between kinds of fruit-trees that have been shown to exist with relation to disease prevalence are neither constant nor parallel with relation to the intensity of

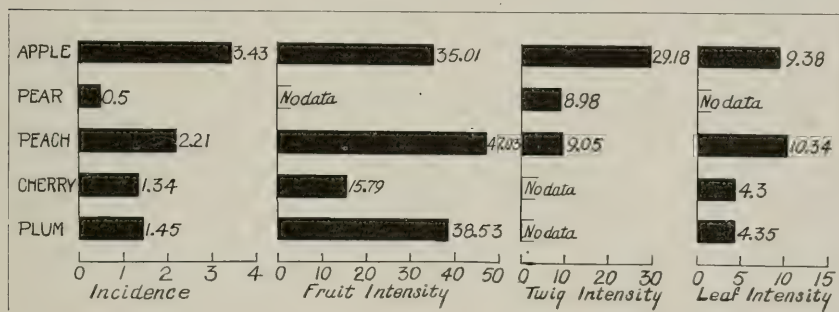


FIG. 31. COMPARISON OF THE AVERAGE ANNUAL PREVALENCE AND INTENSITY OF DISEASE ON FRUIT TREES IN ILLINOIS

The data given in Table XXIV are presented graphically for ready comparison. Incidence of disease shows the average number of diseases attacking each kind of fruit tree, and the total intensity of the attack of these diseases is shown for fruit, leaf, and twig. See text for discussion.

TABLE XXIV

AVERAGE ANNUAL PREVALENCE AND INTENSITY OF FRUIT-TREE DISEASES IN ILLINOIS, AS DETERMINED FROM DATA COVERING THE PERIOD 1922-1928

Kind of tree	Number of diseases included	Incidence of disease per tree	Intensity of disease attack		
			On fruit	On twigs	On leaves
Apple.....	5	3.43	35.01	29.18	9.38
Pear.....	1	.50		8.98	
Peach.....	4	2.21	47.03	9.05	10.34
Cherry.....	2	1.34	15.79		4.30
Plum.....	2	1.55	38.53		4.35

disease attack on fruit, twig, and leaf. The second column of bars in Figure 31 compares the average intensity of fruit-disease on our fruit trees. Though attacked by fewer diseases, as a rule, than the apple, the average peach tree suffers more from fruit-disease, while the plum, with nearly the same incidence of disease as the cherry, suffers over twice as much fruit infection.

The average annual intensity of twig attack, which is compared in the third column of bars in Figure 31 for the apple, pear, and peach, is greatest on the apple, least on the pear, and intermediate on the peach. This order corresponds exactly to the order of disease prevalence.

The average intensity of leaf-disease, shown for all our fruit trees except the pear by the fourth set of bars in Figure 31, is again greatest on the peach, though on the apple it is not much less. On cherry and plum it is about equal, but is, on each, less than half as severe as on peach or apple. The average intensity of leaf-disease runs parallel, in respect to the kind of fruit trees, with the average intensity of fruit-disease on peach and apple, but parallel with the average incidence of disease on plum and cherry trees.

RECAPITULATION

In Illinois, as elsewhere, the productiveness of orchards is curtailed by the injury to trees and their fruit that results from the attack of destructive diseases. Each kind of fruit tree is subject to a particular group of diseases, of which some are serious and some mild. Certain diseases, after obtaining a foot-hold, work continuously to accomplish the death of the trees they attack. Others leave their host-trees during some part of every year and, returning annually at some particular time to renew their attack on special parts of their hosts, exhibit striking variations both in prevalence and in destructiveness, from one year to another. In this respect they are similar to the recurring diseases of mankind and equally deserve to be called epidemic.

Research and investigation have revealed the causes of these diseases, the life histories of the parasites, and the poisons most effective against them. Sprays are, however, seldom completely effective. Often they fail.

To increase the efficiency of disease control, an understanding of the effects of weather variations upon epidemics is necessary. This may be gained by studying simultaneously, and in detail, both the weather and the epidemics. The former has for many years been accurately measured and recorded, but epidemics have not been subjected to a similar scrutiny.

From 1921 through 1928, a survey was made in Illinois of the epidemic diseases of fruit-trees. During these years, methods of measuring the epidemics had to be devised, tested, and perfected; in every year the epidemics were measured with the means at hand, and the measurements were recorded according to definite plans. The full results of this survey are now reported in the text of this paper:

An epidemic is considered to have two primary aspects. These are, first, the prevalence of the disease and, second, the intensity of its attack.

The former we have measured and recorded simply as the percentage of trees succumbing to infection; but the latter, being more complex, has had to be considered from three points of view.

Diseases of an epidemic nature usually produce lesions on fruit, on new and immaturesly lignified twigs, and on leaves. The attack may be on any one, on any two, or on all three of these tree parts, according to the disease. To measure fully the intensity of an epidemic, each phase of its attack must be taken into account and the measurements must be maintained as a separate indicator of the success of the epidemic.

Prevalence and intensity of attack have been measured for 5 apple diseases, 1 pear disease, 4 peach diseases, 2 plum diseases, and 2 cherry diseases. The data so accumulated have been evaluated and reduced to averages, which we have called indexes.

Each epidemic disease has an index of prevalence for each year of the period of our survey, unless data were not obtainable, and, according to the mode of attack characteristic of the particular disease, its annual intensity is represented by one or more indexes. The blotch disease of apple, for example, is given the following indexes for 1922: prevalence, 53.03; intensity of fruit attack, 41.36; intensity of twig attack, 10.49; intensity of leaf attack, 2.56. These indexes, the exact significance of which is fully explained in the section entitled *Analysis of Data*, present a complete evaluation of apple blotch, in all its epidemic aspects, for the summer of 1922. Corresponding sets of indexes for 1923 and each succeeding year state with exactness the increases and decreases of the disease in prevalence and intensity through the period covered by the survey. Sets of indexes for the other epidemic diseases of the apple and for the diseases of other fruit trees make it possible to compare the fluctuations of all the apple diseases with one another from year to year and to compare at will the variations of any disease of any kind of fruit tree with any disease of any other kind of tree. Many such comparisons have been made in the text, both directly from the tabulated indexes or by means of diagrams based on the indexes.

It seldom happens that all the diseases of one kind of fruit tree follow, in one year, the same course of increase or decrease from the previous year. Two diseases may increase in nearly the same proportion from one year to the next, but in the third year their trends are apt to become opposed, one disease continuing to increase, the other manifesting a great diminution in prevalence and in one or more of its phases of intensity.

The changes exhibited from year to year by fruit-tree diseases appear to be governed by no general law. Fluctuations of individual diseases are often so great, and occur in such diverse directions and amounts, as to suggest only capriciousness. The interdependence that might be expected between prevalence and intensity of attack does not occur consistently. High prevalence and mild intensity are often combined, as are also moderate prevalence and high intensity. Of the three phases of disease intensity, one may be high in a given year and the others low, and the changes that occur in succeeding years follow no apparent rule. Evidently, each phase of each disease fluctuates from year to year with considerable independence from the other phases.

To these general statements, there is one exception. The year 1925 proved disastrous to all diseases. Whatever the conditions of that year may have been, whatever their differences from previous and succeeding years, they were beyond doubt so unfavorable that, excepting only apple blotch in its twig phase, no fruit-tree disease was able to achieve significant proportions, either in prevalence or intensity. So fatal was this year to the organisms that cause fruit-tree diseases, that in the three subsequent years included in the survey few diseases have been able to attain their former levels of prevalence and intensity.

The fruit trees of Illinois are of two classes. Apples and pears, with their several-seeded cores, are called pomaceous; while peaches, plums, and cherries, with their hard-pitted fruits, are drupaceous. This botanical separation of the two groups is accompanied by an equally distinct difference in diseases. And more remarkable still, our comparisons show that the fluctuations of disease on pomaceous and on drupaceous trees are nearly always in opposite directions. A year that favors apple and pear disease is detrimental to disease on the drupaceous trees; and, conversely, a year favorable to disease on peaches, plums, and cherries inhibits the development of disease on apples and pears.

In the production of such a diversity of disease phenomena, many elements are combined. As direct causes of disease, there are fungi and bacteria. These have various means for reproducing themselves and various abilities for infecting their hosts through chance openings, by exerting mechanical force, or by accomplishing the chemical dissolution of protective membranes. Success in reproduction, in accomplishment of infection, and in the subsequent growth and extension of these parasites is conditioned and governed by many external factors, among them being light, heat, and moisture. In different amounts or combinations, these factors impede or expedite the production of disease, determine times of infection, and influence reproductive processes. Since the ability of the parasites to maintain themselves vicariously in adverse conditions and to flourish under favorable conditions results in the variations in epidemics, the prevalence and intensity a disease attains is a definite indication of the favorableness of the conditions under which it developed.

Epidemics have now been analyzed and measured, and their characteristics have been stated in terms sufficiently concrete to enable the making of exact comparisons for similar and dissimilar environmental conditions. Of the environment, temperature and precipitation are measured regularly in Illinois and a large mass of data is available. The next step is to determine what combinations of these elements, as indicated by the characteristics of accompanying epidemics, favor or inhibit the development of fruit-tree diseases.

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ERRATA

Page 6, footnote, for *21* read *18*, and omit *31*.

Page 112, first line, for *The* read *This*; tenth line from bottom, for *The Red Oak* read *Q. borealis*.

